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EFFECTS OF ANTI-SEIZING

COMPOUNDS AND LUBRICANTS

ON HIGH TEMPERATURE

ALLOYS AT ELEVATED TEMPERATURES

REPORT AO78

SERIAL NO. 5

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EFFECTS OF ANTI-SEIZING
COMPOUNDS AND LUBRICANTS
ON HIGH TEMPERATURE
ALLOYS AT ELEVATED TEMPERATURES

REPORT A078 SERIAL NO. 5

MCDONNELL

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LABORATORY REPORT

SYSTEMS LABORATORYFINAL REPORTEFFECTS OF ANTISEIZING COMPOUNDS AND LUBRICANTS ON HIGH TEMPERATURE ALLOYS
AT ELEVATED TEMPERATURESABSTRACT

At the present time, very little information is available concerning the metallurgical effects of antiseizing compounds and lubricants on high temperature alloys at elevated temperatures. This test was conducted to gain some background information in this area.

The test was conducted in two phases. The first phase subjected seven different alloys to the effects of twenty two different compounds at a temperature of 1000F for ten hours. In the second phase, six of these alloys were subjected to twenty of the compounds at a temperature of 1800F for ten hours.

The results of the first phase of the test indicate that none of the compounds tested cause significant change in the microstructure of the alloys, observable at 250X, for temperatures up to 1000F. At 1800F, however, considerable corrosion was present. The type and degree of corrosion varied with the different compounds and alloys.

From the results of this test, it could be assumed that any of the compounds tested would be satisfactory for use on these alloys at temperatures to 1000F, but care should be used in selecting an alloy-compound combination for use in the higher temperature range. It should be noted that this report deals only with the metallurgical effects of the compounds tested on metals in the unstressed condition and no reference will be made to the antiseizing, lubricating, or binding capabilities of the compounds. A future series of tests are now being considered for obtaining this information.

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PAGE 2REPORT A07EFINAL REPORT1. INTRODUCTION

A number of antiseizing compounds, lubricants, and binders are now in use or being studied for use, at McDonnell. Very little information is available concerning the metallurgical effects of these compounds on high temperature alloys at elevated temperatures. The intent of this report is to furnish information in this field.

The information contained in this report is based on the results of tests conducted during the period 1 June 1961 through 18 July 1961, by the Methods Test Group, Systems Laboratory, General Engineering Division of McDonnell Aircraft.

The testing was carried out in two phases. In phase one, sets of seven specimens, of different alloys, were placed in twenty three containers containing different compounds. After this the containers were taken to a temperature of 1000°F and held there for ten hours. In phase two, specimens of six of the above alloys were subjected to twenty one of the above compounds and 1800°F for ten hours.

It should be noted that this report deals only with the metallurgical effects of the compounds tested, and no reference will be made to the antiseizing, lubricating, or binding capabilities of the compounds. A future series of test are now being considered for obtaining this information.

2. DESCRIPTION OF TEST ARTICLES

Seven different alloys and twenty two different compounds were tested, (one container in each of the two phases contained only the specimens and ambient air) they are as follows:

2.1 Alloys

- (A) Inconel X: 0.04C, 0.7 Mn, 0.5 Si, 15 Cr, 73 Ni, 1Co, 2.5 Ti, 0.9 Al, 7 Fe.
- (B) A-286: 0.08C, 1.35 Mn, 0.5 Si, 15 Cr, 25 Ni, 1.25 Mo, 2 Ti, 0.25 Al, 0.5 V, remainder Fe.
- (C) Rene '41: 0.10C, 19 Cr, 11 Co, 10 Ni, 3 Ti, 1.5 Al, 3 Fe, Trace B, Remainder Ni.
- (D) L-605: 0.15C, 1.5 Mn, 0.5 Si, 20 Cr, 10 Ni, 15 W, 2 Fe, Remainder Co.
- (E) Hastelloy X: 0.15C, 22 Cr, 9 Ni, 20 Fe, Remainder Ni.

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(F) 310 S.S.: 0.25 C, 2 Mn, 1.5 Si, 25 Cr, 20 Ni, Remainder Fe.

(G) 4130 STL: (1000F phase only) 0.3C, 0.5 Mn, 0.04 P, 0.04S, 0.3 Si, 1 Cr, 0.2 Mo, Remainder Fe.

NOTE: The above figures are approximate percentages of the elements present in the alloys; therefore, they may not add up to 100%.

2.2 Compounds

(A) Silver Goop: (Antiseizing Compound) Manufactured by Crawford Pitting Company, Cleveland, Ohio. A metallic, fluid, paste, designed for use on high temperature alloys, at temperatures up to 2000F. Composition: aluminum oxide (Al_2O_3), graphite, magnesium oxide (MgO), silver and silica (SiO_2).

(B) Crane 425A: (Antiseizing Compound) Manufactured by Crane Plumbing Supply Company, St. Louis, Missouri. A thick, brown paste, designed for use at temperatures to 1050F. Composition: information not released by vendor. (Used in 1000F phase only.)

(C) Ease Off 990: (Antiseizing Compound) Manufactured by the Talcose Company, Dallas, Texas. A thick brown paste, designed for use at temperatures to 1800F. Composition: molybdenum disulfide (MoS_2), lead oxide PbO, and graphite.

(D) Fel-Pro CSA: (Antiseizing Compound) Manufactured by Felt Products Manufacturing Company, Skokie, Illinois. A thick metallic paste, designed for use at temperatures to 1800F. Composition: colloidal copper base.

(E) DGF 123: (Lubricant) Manufactured by Miracle Power Products Corporation, Cleveland, Ohio. A black aerosol spray. Composition: graphite.

(F) MIL-X-5544-A: (Antiseizing Compound) The compound tested was manufactured by Permatex Company, Incorporated, Kansas City, Kansas. A thick, black paste, designed for use at temperatures to 1200F. Composition: 50% graphite and 50% petrolatum.

(G) Electrafilm 1000: (Lubricant) - Compound manufactured and applied by Dynasraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 1500F. Composition: graphite and lead oxide (PbO).

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2.2 Compounds (cont'd.)

- (H) **Electrofilm 1005: (Lubricant) Compound** manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 700°F in air (to 2000°F in vacuum). Composition: molybdenum disulfide (MoS_2).
- (I) **Electrofilm 2006: (Antiseizing Compound) Compound** manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin black electrically bonded film, designed for use at temperatures to 800°F in air (to 2000°F in vacuum). Composition: graphite.
- (J) **Electrofilm 660: (Antiseizing Compound) Compound** manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 600°F in air (to 2000°F in vacuum). Composition: molybdenum disulfide (MoS_2) and graphite.
- (K) **Phosphatherm RH: (Antiseizing Compound) Manufactured** by The Alpha Molykote Corporation, Stamford, Connecticut. A coarse, pink, powder designed for use at temperatures to 2200°F. Composition: potassium, sodium, and phosphorus pentoxide (P_2O_5).
- (L) **Molykote X-106M: (Lubricant) Manufactured** by The Alpha Molykote Corporation, Stamford, Connecticut. A thin, black, metallic, liquid, designed for use at temperatures to 700°F in air (to 2000°F in vacuum). Composition: molybdenum disulfide (MoS_2) (Used in 1000°F phase only).
- (M) **Molykote X-106: (Lubricant) Same** as Molykote X-106M with the exception of the material used as a binder.

NOTE: The materials listed under composition for the above commercial compounds are only the basic components. Complete information on the composition of these compounds is, in most cases, unavailable.

- (N) **Sodium Silicate: (Binder)** A thick, clear, liquid (Na_2SiO_3)
- (O) **Silica: (Binder)** A fine, white powder. (SiO_2); A.C.S. pure grade.
- (P) **Milk of Magnesia (Antiseizing Compound)** A thick white liquid. $\text{Mg}(\text{OH})_2$; U.S.P. grade
- (Q) **Magnesium Oxide: (Antiseizing Compound)** A fine white powder. (MgO); A.C.S. reagent grade.

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LABORATORY REPORT**2.2 Compounds (Cont'd.)****FINAL REPORT**

- (R) Boron Nitride: (Antiseizing Compound). A fine white powder. (BN); commercial grade.
- (S) Boric Oxide: (Binder) A fine white granular compound. (B_2O_3); A.C.S. reagent grade.
- (T) Lead Monoxide: (Lubricant) A fine, yellow, powder. (PbO): H.F. IX grade.
- (U) Calcium Fluoride: (Lubricant) A fine, white powder (CaF_2); A.C.S. reagent grade.
- (V) Lead Sulfide: (Lubricant) A coarse, black powder. (PbS); A.C.S. reagent grade.

3. TEST SETUP

Containers for the specimens and compounds were fabricated from 301 S.S. sheet and tube stock. Materials for specimens were obtained and machined, when required, and cut to the required dimensions (see Figure A page 9).

For the 1000F phase of the test sets of seven specimens, one of each material type (see "Description of Test Articles, Alloys", page 2) were placed in twenty three different containers. The specimens were suspended on stainless steel wire and separated by ceramic bead spacers so the specimens could not come into contact with each other or the containers. White sand, which was used as a seal to retard the circulation of air into the containers, was added to the outer area of the container. Then the inner area of the containers, which contained the specimens, was blown clean with high pressure air, to remove foreign particles, in preparation for the addition of the compounds and high temperature exposure. (See Figure B, page 10).

For the 1800F phase of the test, the same containers were cleaned and reused for their respective compounds. The specimens were placed in their containers in the same manner as for the 1000F phase, except there were only six specimens in each set due to the fact that the 4130 steel specimens were omitted because of the temperature limitations of this material. Also, only twenty one containers were used because two compounds were omitted. One (Grane 425A) was omitted because of temperature limitations, and the other (Kalykote E-100N) because of not being available at the time of test.

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4. TEST PROCEDURE

All compounds tested, with the exception of the Elektrofilm series, which were electrically bonded to the specimens by Dynacraft Corporation, St. Louis, Missouri, were added to the containers after the specimens were mounted in them. The containers were then placed in an air atmosphere furnace, in the Materials and Methods Laboratory, and held at 300°F for approximately one hour to drive off volatile substances. The lids were then placed on the containers and they were subjected to high temperature exposure.

For the 1000°F phase of the test, the twenty-three containers; twenty two contained the various compounds, see "Description of Test Articles, Compounds", page 3) and one, for control specimens, containing ambient air; were placed in an air atmosphere furnace. Then the specimens were heated to a temperature of 1000°F and held at this temperature for ten hours, and allowed to air cool to room temperature. The specimens were then removed from the containers, and the containers were cleaned in preparation for use in the 1800°F phase of the test.

For the 1800°F phase, the twenty one containers; twenty containing the compounds to be tested (see "Description of Test Articles, Compounds" page 3) and one, for control specimens, containing ambient air; were placed in an air atmosphere furnace and heated to a temperature of 1800°F, held at this temperature for ten hours and allowed to air cool to room temperature. After this, they were removed from the containers to be mounted and polished.

A transverse and longitudinal sample were cut from each specimen. These were mounted in a clear plastic (Epon 828 resin, using diethylene triamine for catalyst). After this, the samples were ground and polished for metallographic examination. The samples from the 1000°F exposure were then etched and photomicrographs taken of the transverse samples. Photomicrographs were obtained prior and subsequent to the 1800°F exposure tests.

5. TEST RESULTS

The photomicrographs of the transverse samples from the 1000°F exposure show that the compounds tested caused no significant change in the microstructure of the alloys exposed (see Figures 1 through 161) pages 12 through 65.

The photomicrographs of the 1800°F exposure samples (see Figures 162 through 415, pages 66 through 195) show a wide variety of effects, ranging from no attack to very severe corrosive action (see Table 1, page 8).

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5. TEST RESULTS (Cont'd.)

The results of this phase of the test show that several of the compounds tested would be unsatisfactory for use in this temperature range.

6. DISCUSSION OF TEST RESULTS

The results of the 1800F phase of this test, indicate that three of the compounds tested caused no significant corrosive attack (i.e. the corrosion present was of the same type and did not exceed the rate of corrosion of the control specimens, which were exposed to only air) to any of the alloys tested, for temperatures up to 1800F. These three compounds, Fel-Pro C5-A, Boron Nitride, and Milk of Magnesia, were the least corrosive. At the other end of the scale was Ease-Off 990, Phosphatherm RH, Nolykote X-106, and lead sulfide. These four compounds severely attacked all the alloys tested. The corrosive action of the other 13 compounds tested to 1800F varied within the range of these two extremes. Some of these compounds attacked a few of the alloys while leaving the others untouched, and some of them slightly attacked all the alloys. The remainder of the compounds displayed a combination of both of these vices by slightly attacking some alloys and severely attacking others.

These results indicate that certain facts, such as the alloy the compound is to be used on and the amount of corrosion allowable, should be taken into consideration before these compounds are used.

Another factor to be considered is the temperature at which the compounds are used. Since the temperature spread between 1000F, where no corrosion was observed, and 1800F, where considerable corrosion was observed, is quite large, the results here are not too conclusive.

7. CONCLUSIONS

The fact that no significant amount of attack was present on the specimens subjected to the 1000F phase of this test, indicates that all the compounds tested would be satisfactory for use up to this temperature.

The amount of corrosion present on the specimens subjected to the 1800F phase of this test shows that care should be taken in selecting a compound for use in this temperature range.

It should be noted that this report deals only with the metallurgical effects of the compounds tested on metals in the unstressed condition and no reference will be made to the antisizing, lubricating or binding capabilities of the compounds. A future series of tests are now being considered for obtaining this information.

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TABLE 1
CORROSIVE EFFECTS OF COMPOUNDS ON ALLOYS AT 1800°F

	Inconel				Hastalloy	
	X	A-286	Rene '41	L-605	X	310 S. S.
Silver Soap	Good	Good	Fair	Good	Good	Poor
Base Oil 990	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor
Fel-Pro 65-A	Good	Good	Good	Good	Good	Good
DGF 123	Good	Fair	Good	Good	Fair	Good
MIL-T-5544-A	Fair	Good	Fair	Fair	Good	Poor
Electrofilm 1000	Fair	Fair	Good	Fair	Fair	Poor
Electrofilm 1005	Poor	Good	Fair	Fair	Fair	Poor
Electrofilm 2007	Fair	Fair	Fair	Fair	Poor	Poor
Electrofilm 66C	Fair	Good	Fair	Fair	Poor	Fair
Phosphaterra RM	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor
Sodium Silicate	Fair	Good	Fair	Poor	Fair	Fair
Silica	Good	Good	Poor	Good	Good	Good
Milk of Magnesia	Good	Good	Good	Good	Good	Fair
Magnesium Oxide	Fair	Good	Poor	Poor	Poor	Good
Baron Nitride	Good	Good	Good	Good	Good	Good
Boric Oxide	Fair	Good	Good	Good	Poor	Poor
Molykote X-106	V. Poor	V. Poor	V. Poor	Poor	V. Poor	V. Poor
Lead Monoxide	Poor	Fair	Poor	Poor	Poor	Poor
Calcium Fluoride	Good	Good	Good	Poor	Poor	Fair
Lead Sulfide	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor

EXPLANATION OF DESIGNATIONS

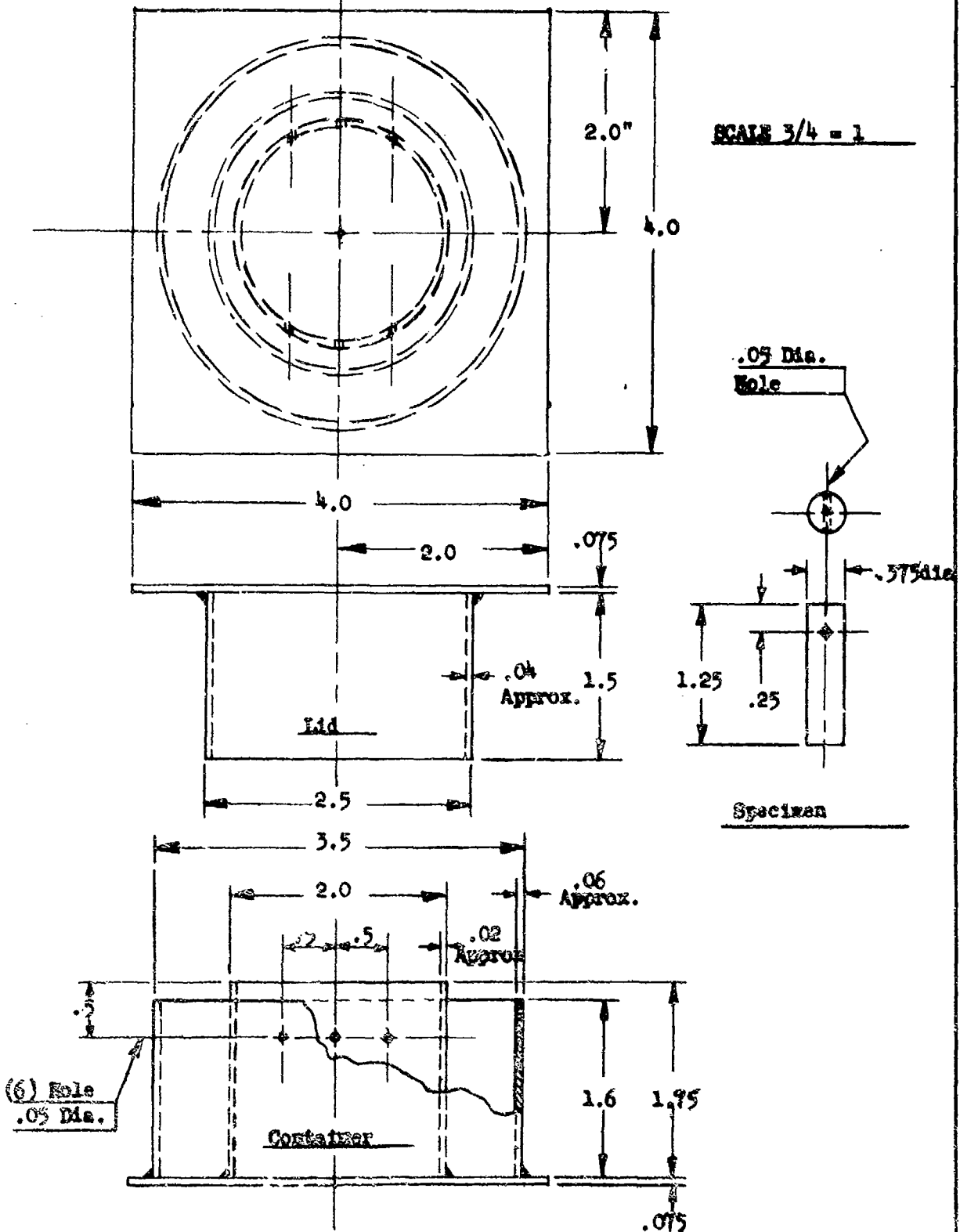
Good	Fair	Poor	V. Poor
Corrosion is of same type and doesn't exceed rate of control specimens (in air).	Corrosion slightly exceeds and/or is of a different type than control.	Considerable amount of corrosion is present.	Severe corrosive attack is evident.

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FIGURE A



TYPICAL CONFIGURATION OF CONTAINER, LID, AND SPECIMEN

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**ASSEMBLY OF SPECIMENS FOR
TESTING ANTI-SEIZE COMPOUNDS
T.R. 513-218**

NOTE

- A. WHITE SAND
- B. STAINLESS STEEL WIRE
- C. CERAMIC BEADS

0 1 2 3 4 5 6

SCALE IN INCHES

TYPICAL

SPECIMEN



SPECIMENS IN CONTAINER



CONTAINER LID

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TABLE 2

EXPLANATION OF ETCHANT CODES

Etchant Code	Common Name	Composition	Alloys Used On
A	Karbless	20g CuSO ₄ 100 ml HCl 100 ml water	Inconel X
B	- - - -	1 ml HNO ₃ 3 ml HCl 3 ml glycerine	A-286
C	Hydrochloric Peroxide	HCl 30% H ₂ O ₂ added by drops as needed.	Remo'41 L-603 Inconel X
D	10% Oxalic	1 ml H ₂ C ₂ O ₄ 9 ml water (electrolytic)	310 S.S.
E	Picral	4g C ₆ H ₅ O ₇ H ₃ 100 ml C ₂ H ₅ OH	4130 Steel
U	- - -	Unetched - - -	

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N 4555

Silver Goop On Inconel X

Figure 1

Mag: 250X

1000⁹⁷

Etch: A



N 4556

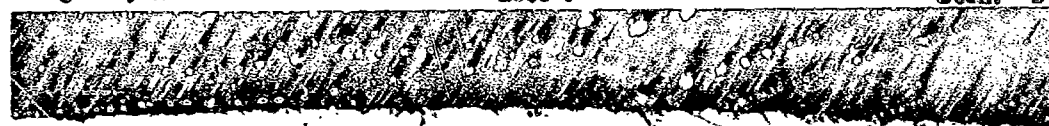
Silver Goop on 1-436

Figure 2

Mag: 250X

1000⁹⁷

Etch: B



N 4557

Silver Goop on Bond 41

Figure 3

Mag: 250X

1000⁹⁷

Etch: C



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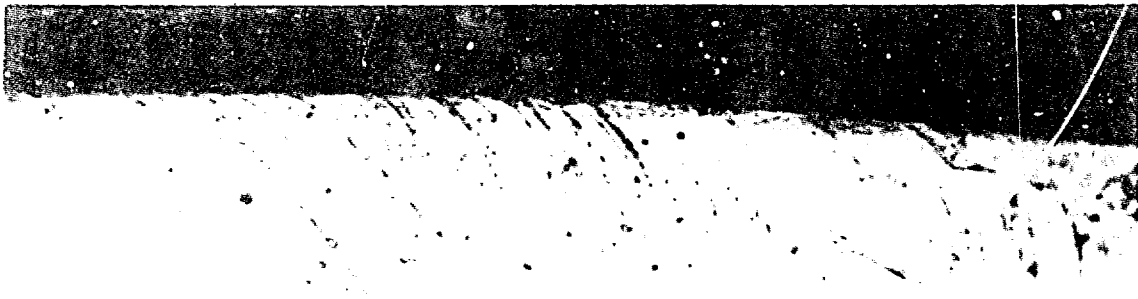
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M 4558
Mag: 250X

Silver Coop on L-605
1000°F

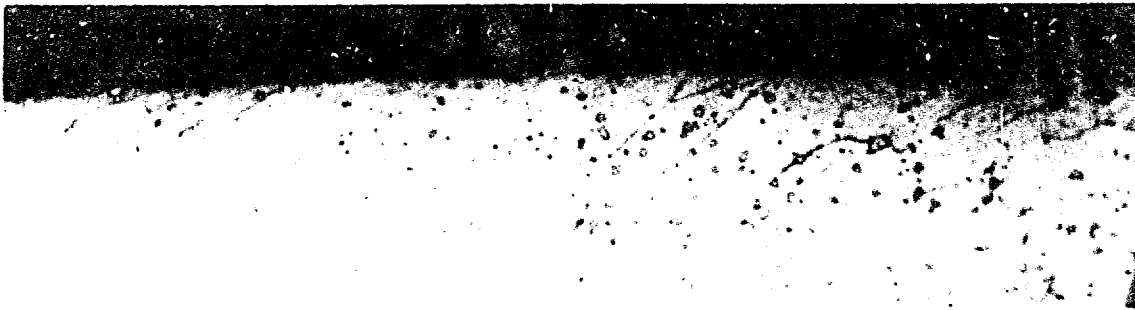
Figure 5
Etch: C



M 4559
Mag: 250X

Silver Coop on Hastalloy X
1000°F

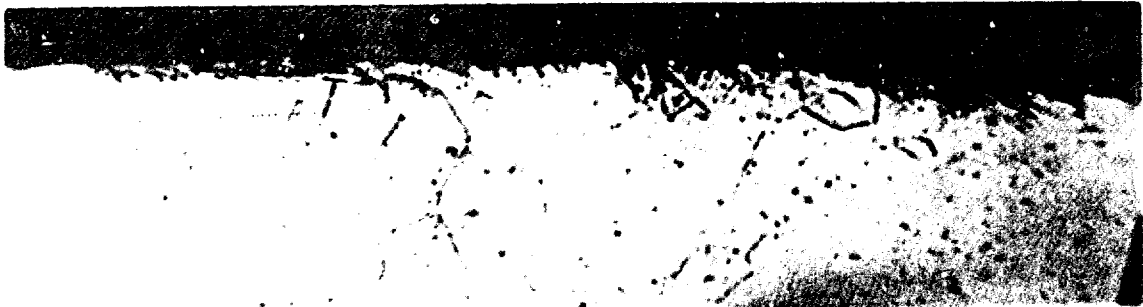
Figure 6
Etch: C



M 4560
Mag: 250X

Silver Coop on 310 SS
1000°F

Figure 7
Etch: D



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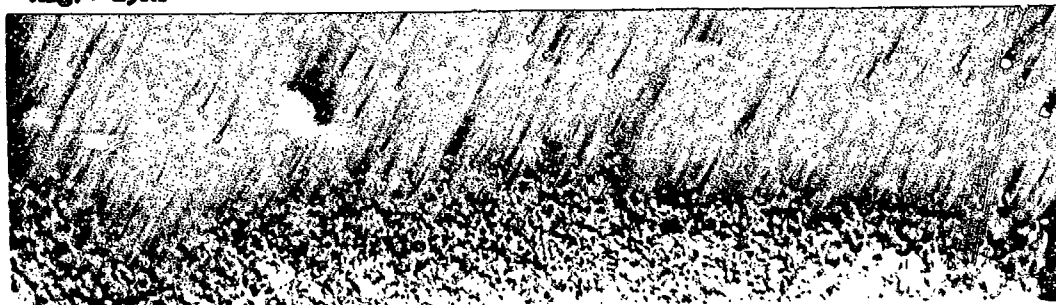
BY: LEANDER G. LARSEN

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M 4561
Mag: 250X

Silver Coop on 4130 Steel
1000°F

Figure 7
Etch: E



M 4562
Mag: 250X

Crane 425A on Inconel X
1000°F

Figure 8
Etch: A



M 4563
Mag: 250X

Crane 425A on A-286
1000°F

Figure 9
Etch: B



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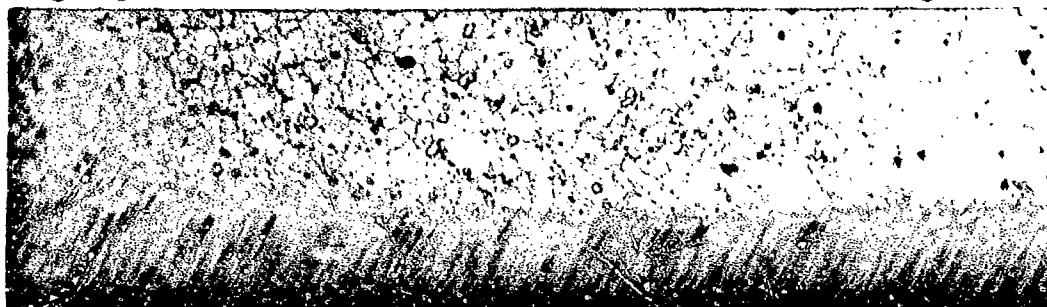
Crane 409A on Road 41

Figure 10

Mag: 250X

1000°7

Etch: C



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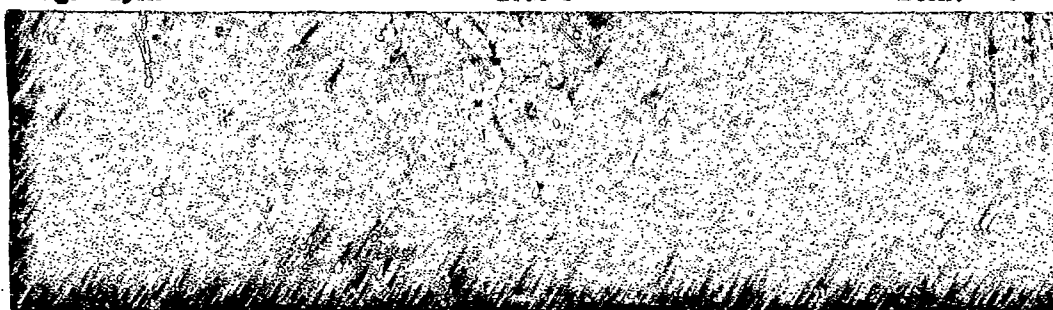
Crane 409A on L-605

Figure 11

Mag: 250X

1000°7

Etch: C



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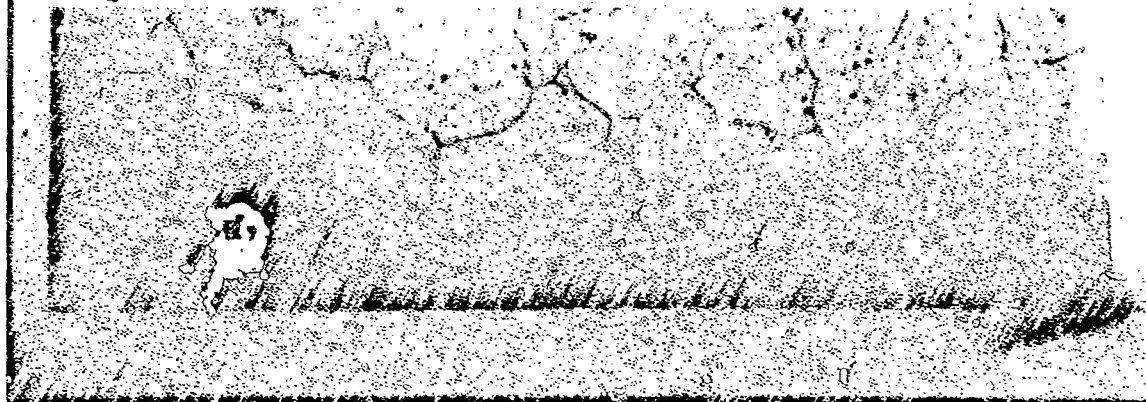
Crane 409A on Installation X

Figure 12

Mag: 250X

1000°7

Etch: C



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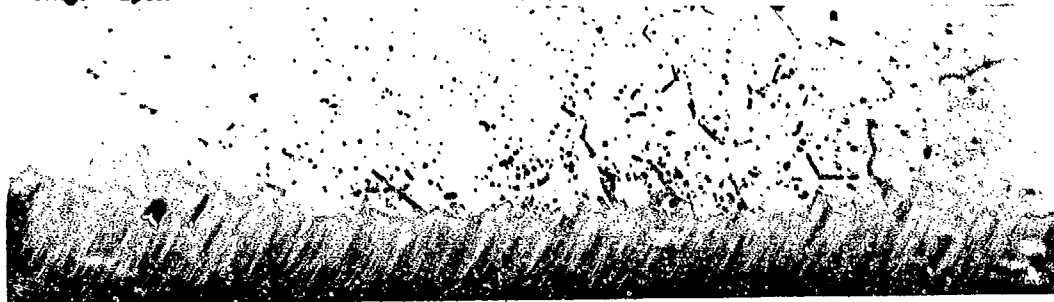
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M 4567
Mag: 250X

Crane 425A on 310 SS
1000°F

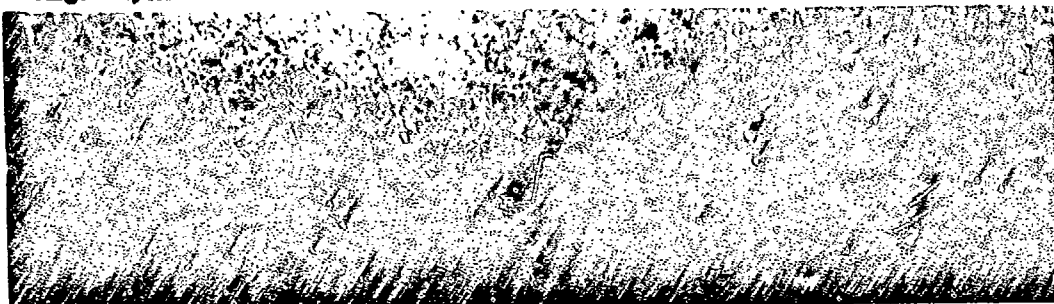
Figure 13
Etch: D



M 4568
Mag: 250X

Crane 425A on 4130 Steel
1000°F

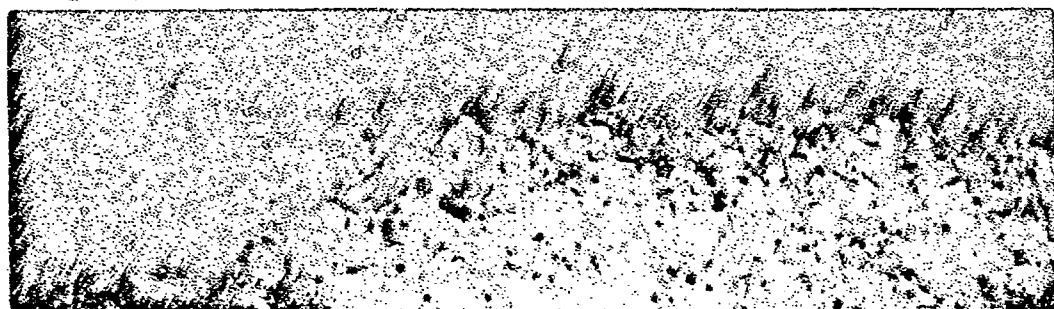
Figure 14
Etch: E



M 4569
Mag: 250X

Base Off 990 on Inconel X
1000°F

Figure 15
Etch: A



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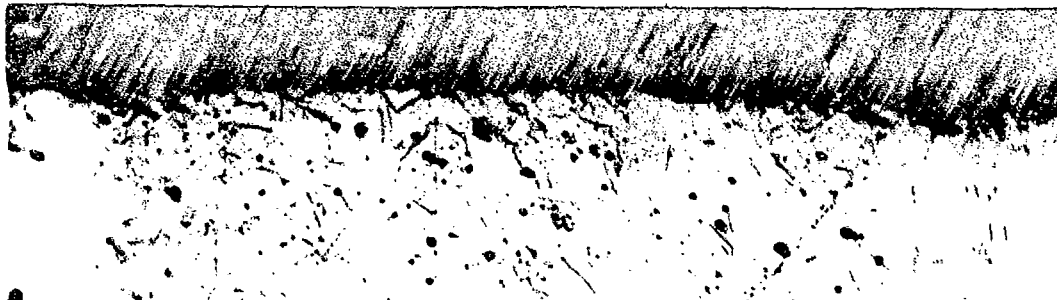
Base Off 990 on A-286

Figure 16

Magn: 250X

10000X

Etch: B



N 4571

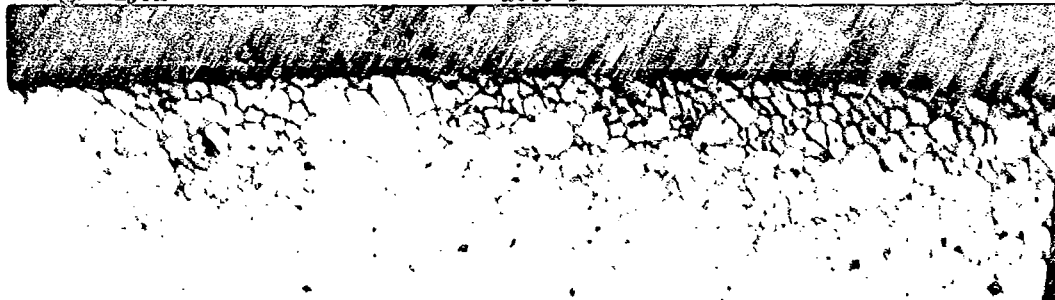
Base Off 990 on Rock 41

Figure 17

Magn: 250X

10000X

Etch: C



N 4572

Base Off 990 on L-603

Figure 18

Magn: 250X

10000X

Etch: C



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N 4573

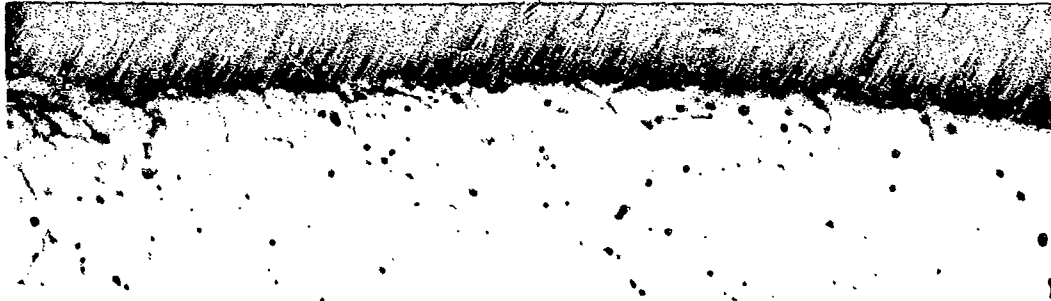
Base Off 990 on Eastellay X

Figure 19

Mag: 250X

1000⁰⁷

Etch: C



N 4574

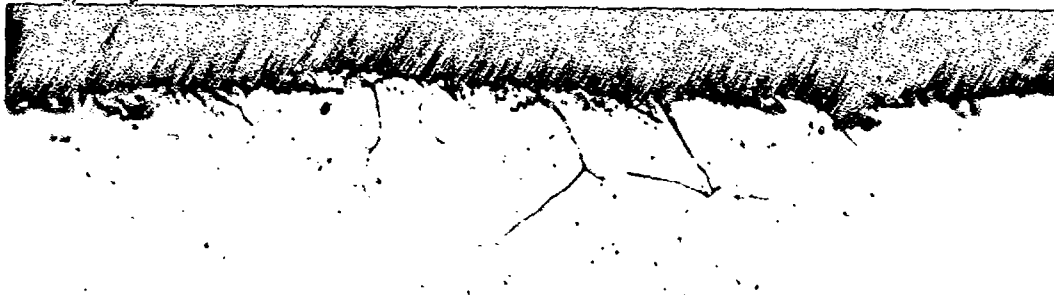
Base Off 990 on 310 SS

Figure 20

Mag: 250X

1000⁰⁷

Etch: D



N 4575

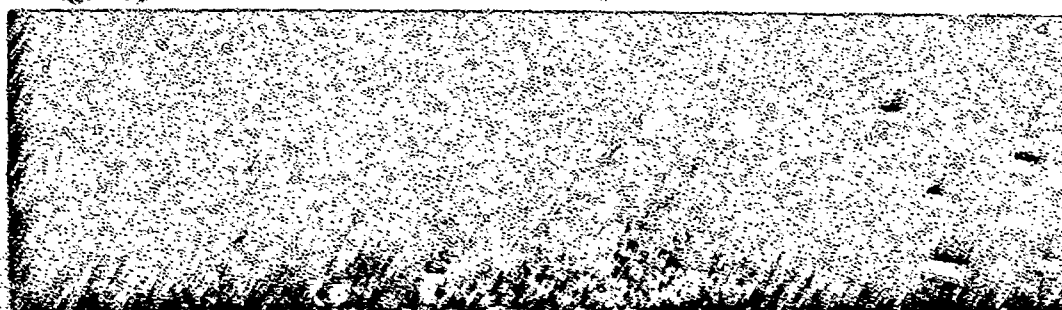
Base Off 990 on 4130 Steel

Figure 21

Mag: 250X

1000⁰⁷

Etch: E



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M 4576

Fel-Pro 65-A on Inconel X

Figure 22

Mag: 250X

1000°F

Etch: A



M 4577

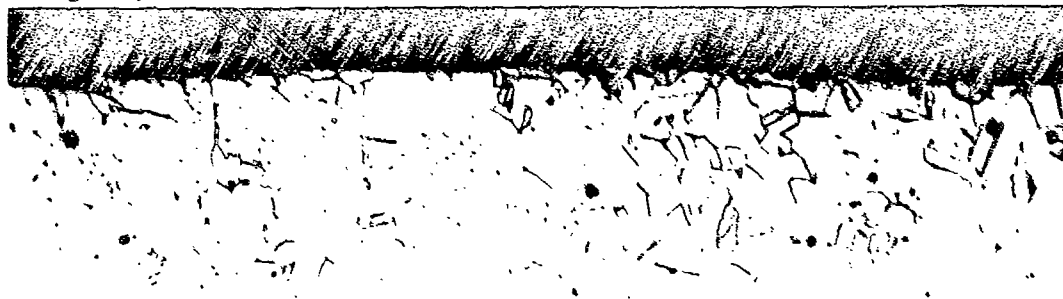
Fel-Pro 65-A on A-286

Figure 23

Mag: 250X

1000°F

Etch: B



N 4578

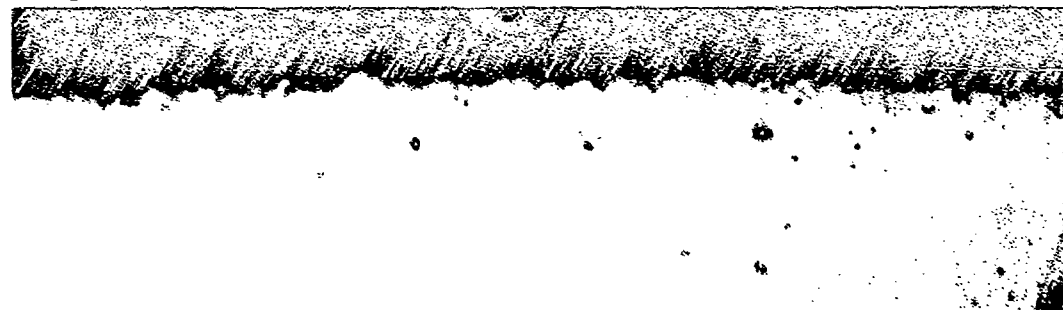
Fel-Pro 65-A on René 41

Figure 24

Mag: 250X

1000°F

Etch: C



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M 4579

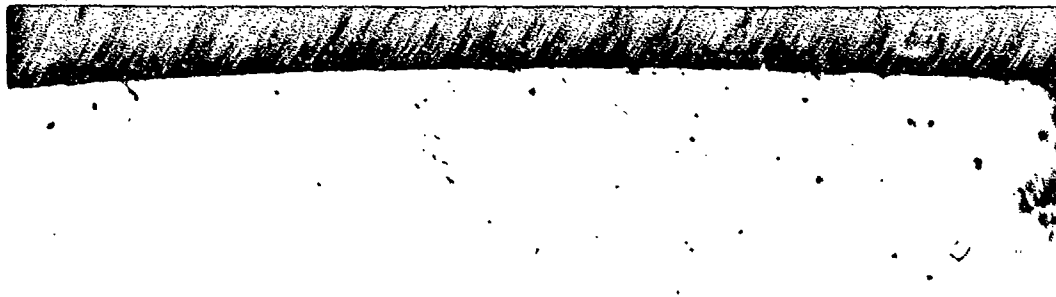
Fel-Pro 65-A on L-605

Figure 25

Mag: 250X

1000°F

Etch: C



M 4580

Fel-Pro 65-A on Hastelloy X

Figure 26

Mag: 250X

1000°F

Etch: C



M 4581

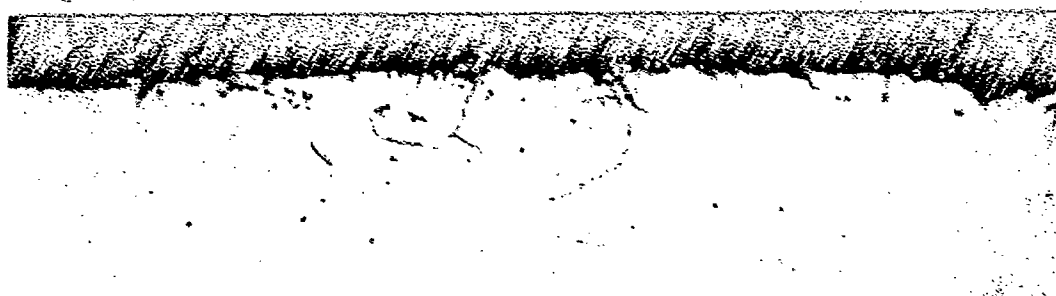
Fel-Pro 65-A on 310 SS

Figure 27

Mag: 250X

1000°F

Etch: C



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M 4582

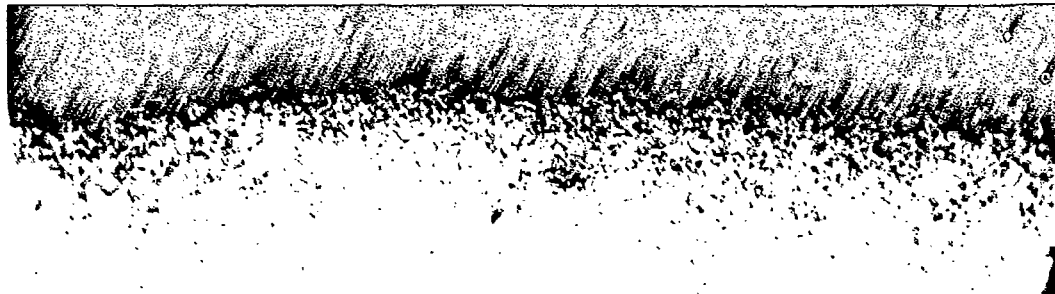
Fel-Pro 65-A on 4130 Steel

Figure 28

Mag: 250X

1000°F

Etch: E



M 4583

DCF-123 on Inconel X

Figure 29

Mag: 250X

1000°F

Etch: A



M 4584

DCF-123 on A-286

Figure 30

Mag: 250X

1000°F

Etch: A

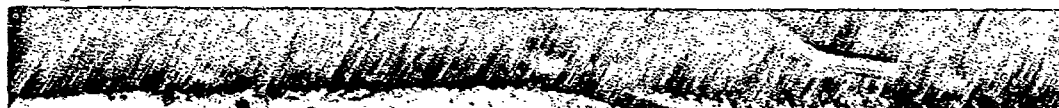


NY 100-249610

Etch: C



Etch: C



Encl: 2



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N 4588

DGP-123 on 310 MS

Figure 34

Mag: 250X

1000°F

Etch: D



N 4589

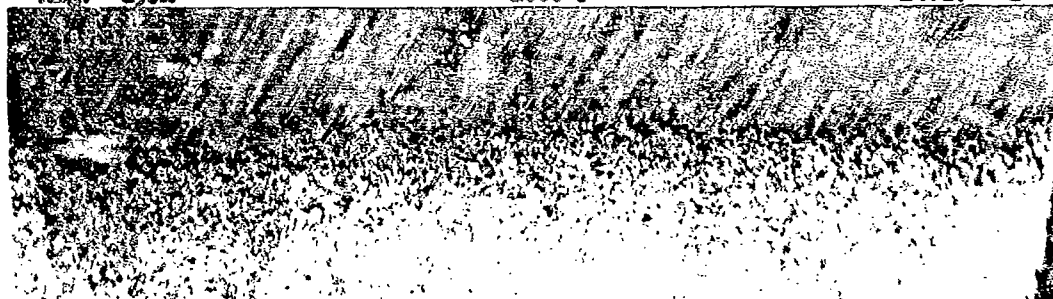
DGP-123 on 4130 Steel

Figure 35

Mag: 250X

1000°F

Etch: E



N 4590

MIL-C-5544 on Inconel X

Figure 36

Mag: 250X

1000°F

Etch: A



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M 4591

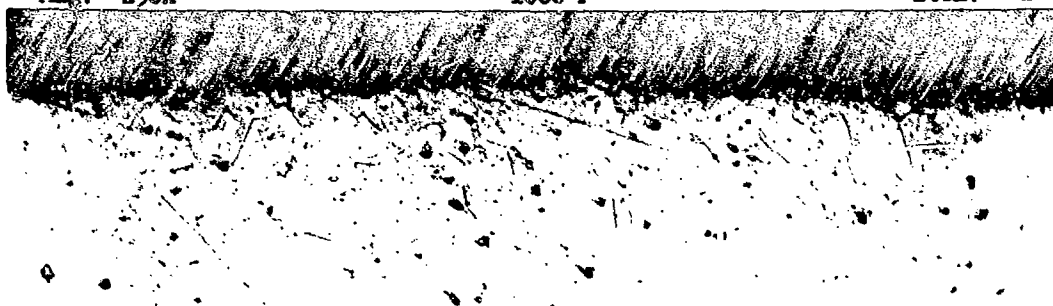
MIL-C-5544 on A-286

Figure 37

Mag: 250X

1000°F

Etch: B



M 4592

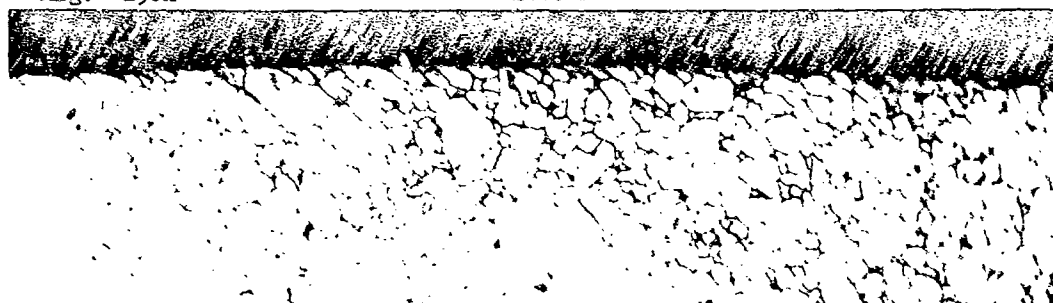
MIL-C-5544 on Rene 41

Figure 38

Mag: 250X

1000°F

Etch: C



M 4593

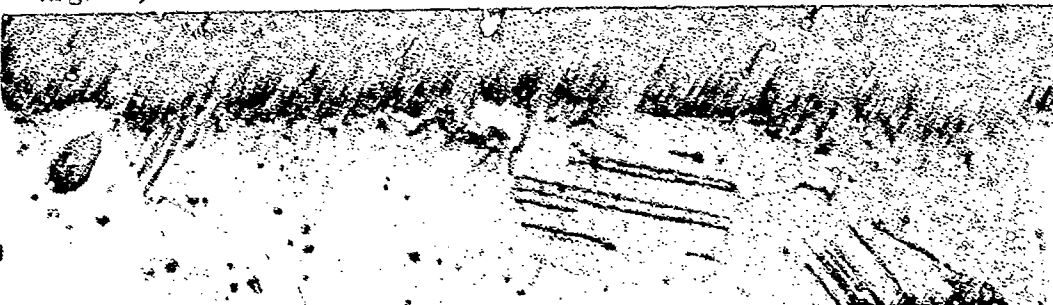
MIL-C-5544 on L-605

Figure 39

Mag: 250X

1000°F

Etch: C



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M 4594

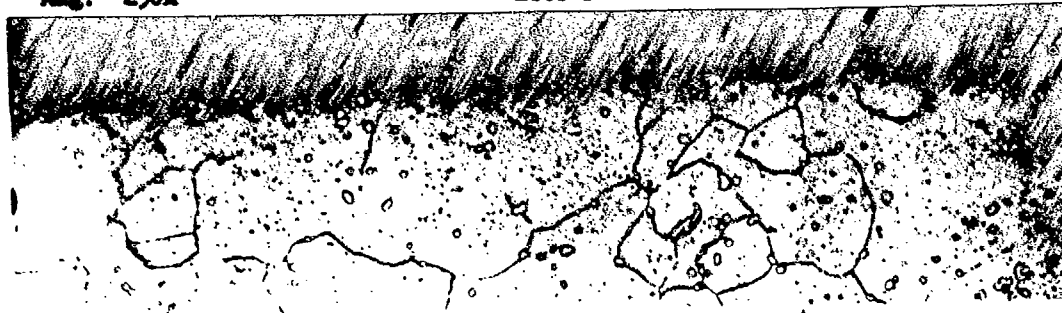
MIL-C-5544 on Hastelloy X

Figure 40

Mag: 250X

1000°F

Etch: C



M 4595

MIL-C-5544 on 310 SS

Figure 41

Mag: 250X

1000°F

Etch: D



M 4596

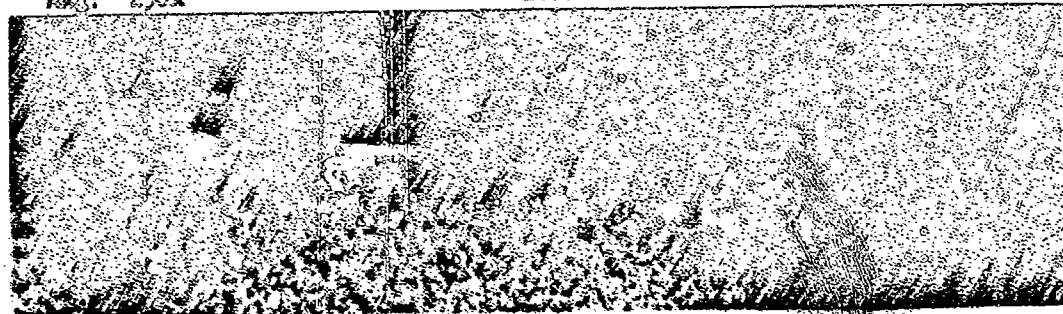
MIL-C-5544 on 4130 Steel

Figure 42

Mag: 250X

1000°F

Etch: E



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M 4597

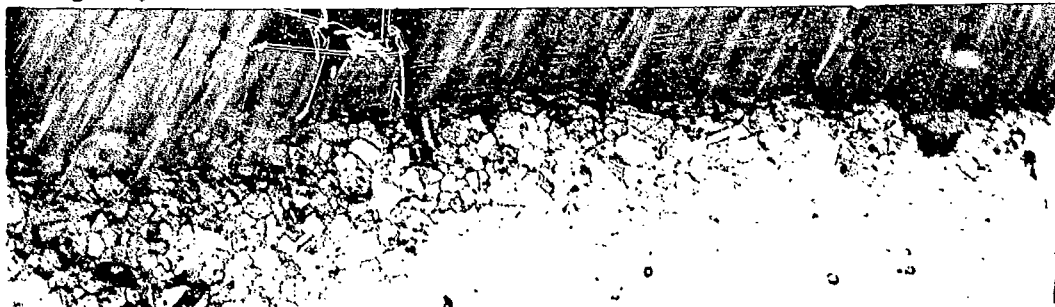
Electrofilm 1000 on Inconel X

Figure 43

Mag: 250X

1000°F

Etch: A



M 4598

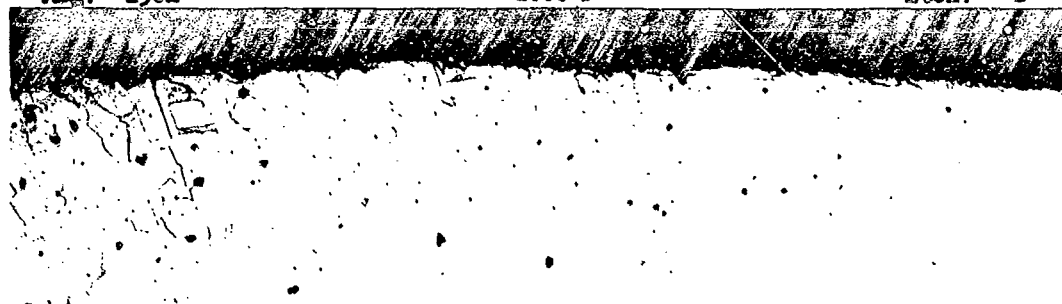
Electrofilm 1000 on A-286

Figure 44

Mag: 250X

1000°F

Etch: B



M 4599

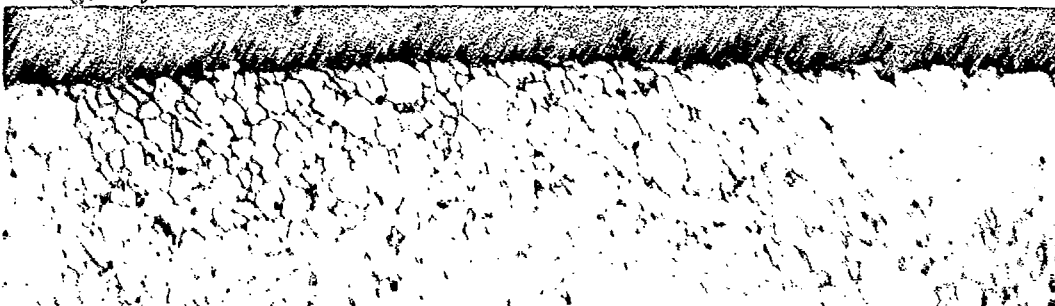
Electrofilm 1000 on René '41

Figure 45

Mag: 250X

1000°F

Etch: C



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M 4600

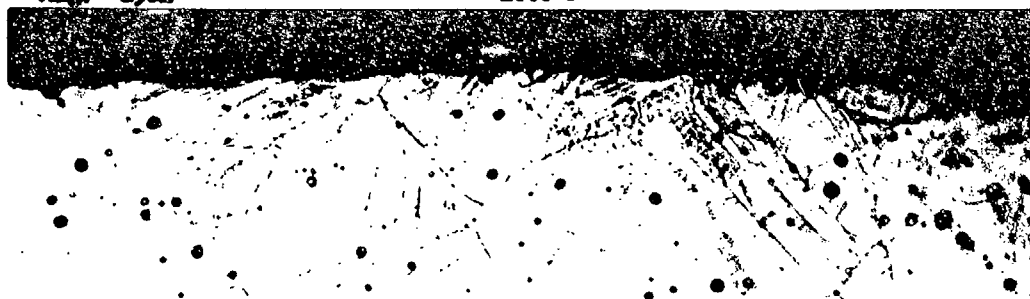
Electrofilm 1000 on L-605

Figure 46

Mag: 250X

1000°F

Etch: C



M 4601

Electrofilm 1000 on Hastelloy X

Figure 47

Mag: 250X

1000°F

Etch: C



M 4602

Electrofilm 1000 on 310 SS

Figure 48

Mag: 250X

1000°F

Etch: D



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M 4603

Electrofilm 1000 on 4130 Steel

Figure 49

Mag: 250X

1000°F

Etch: E



M 4604

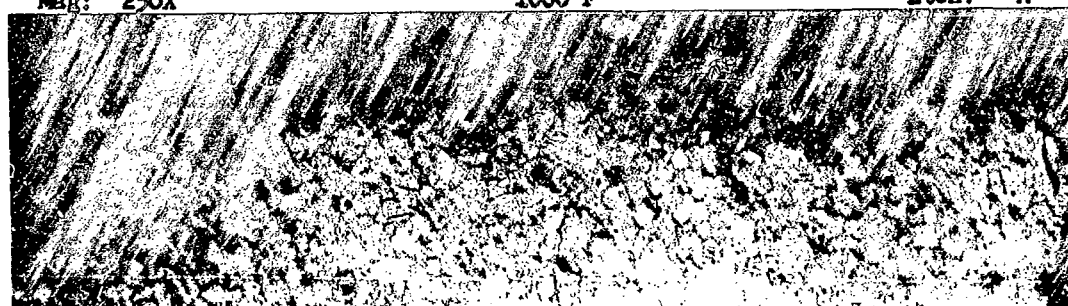
Electrofilm 1005 on Inconel X

Figure 50

Mag: 250X

1000°F

Etch: A



M 4605

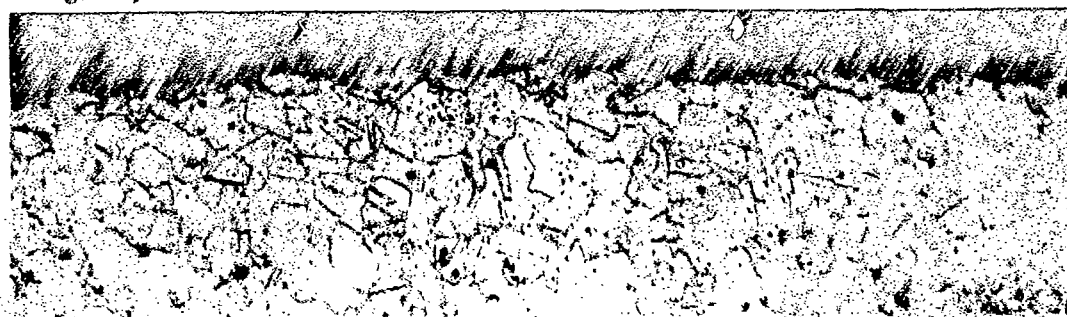
Electrofilm 1005 on A-286

Figure 51

Mag: 250X

1000°F

Etch: B



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N 4606

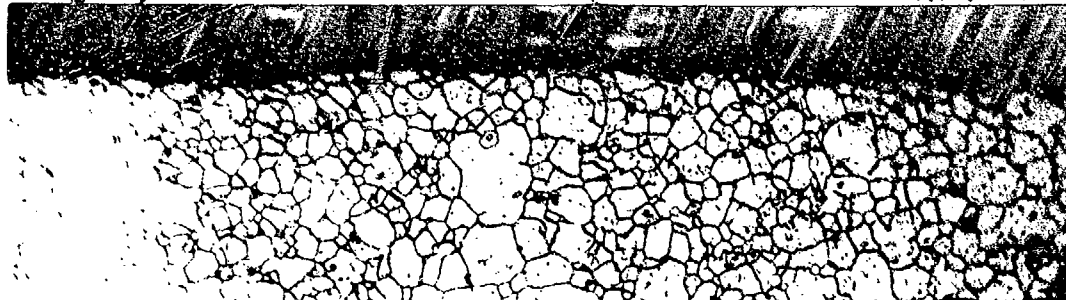
Electrofilm 1005 on Rand 41

Figure 52

Mag: 250X

1000°F

Etch: C



N 4607

Electrofilm 1005 on L-605

Figure 53

Mag: 250X

1000°F

Etch: C



N 4608

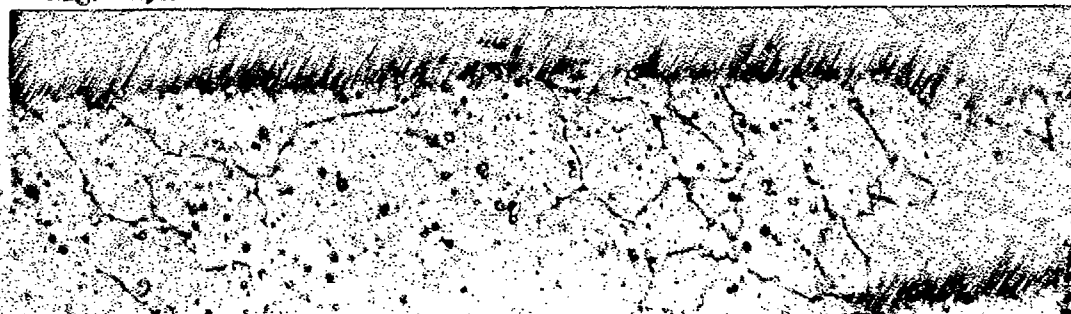
Electrofilm 1005 on Hastelloy X

Figure 54

Mag: 250X

1000°F

Etch: C



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M 4609

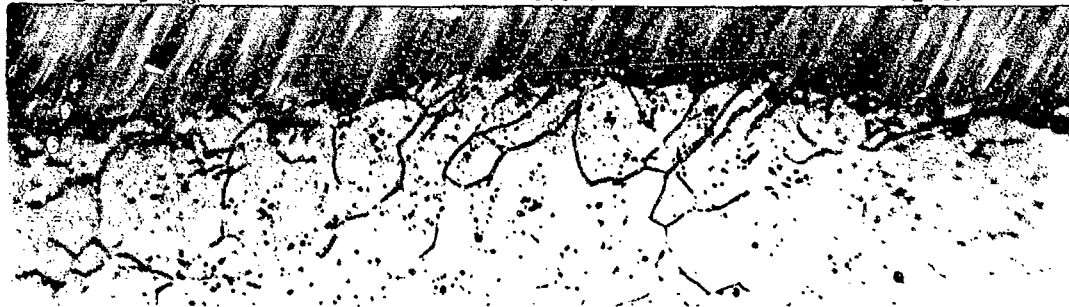
Electrofilm 1005 on 310 SS

Figure 55

Mag: 250X

1000°F

Etch: D



M 4610

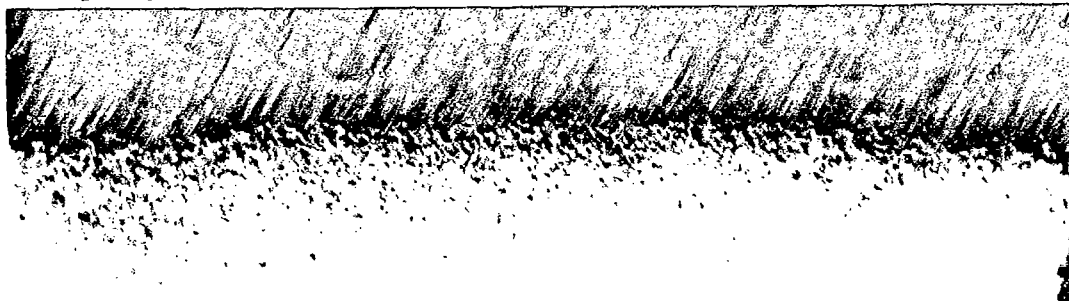
Electrofilm 1005 on 4130 Steel

Figure 56

Mag: 250X

1000°F

Etch: E



M 4611

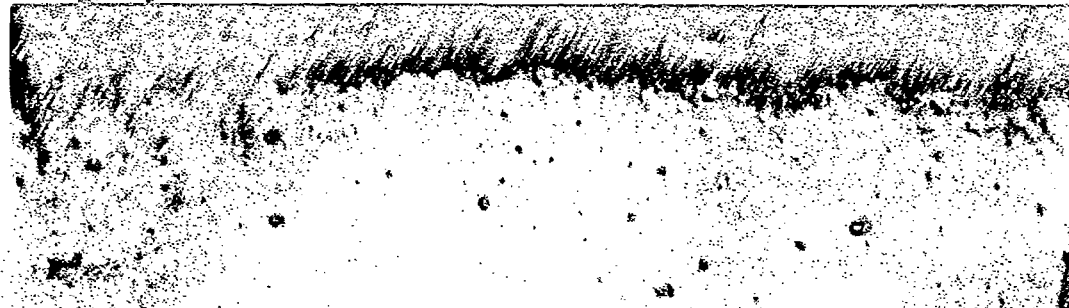
Electrofilm 2007 on Inconel X

Figure 57

Mag: 250X

1000°F

Etch: A



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N 4612

Electrofilm 2007 on A-286

Figure 58

Magn: 250X

10000X

Etch: B



N 4613

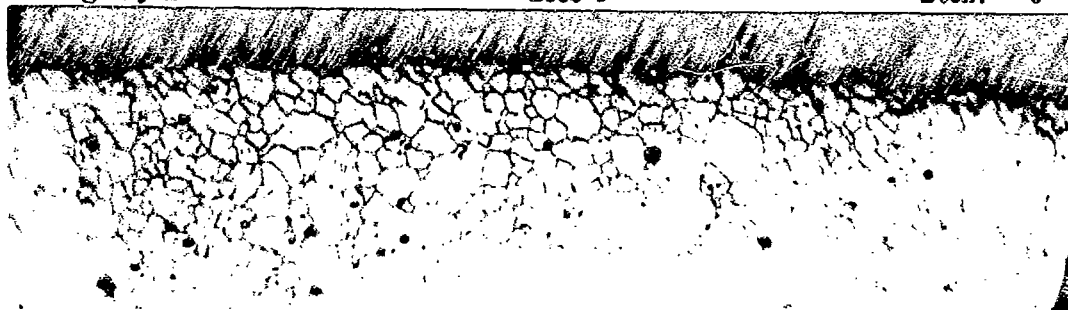
Electrofilm 2007 on René 41

Figure 59

Magn: 250X

10000X

Etch: C



N 4614

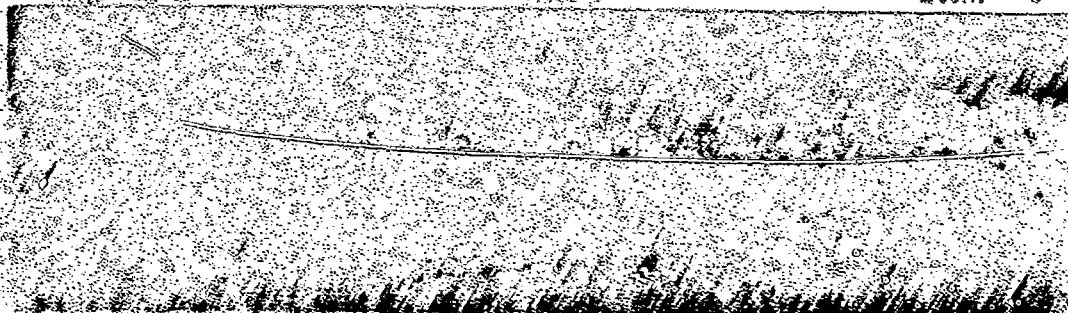
Electrofilm 2007 on L-605

Figure 60

Magn: 250X

10000X

Etch: C



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M 4615

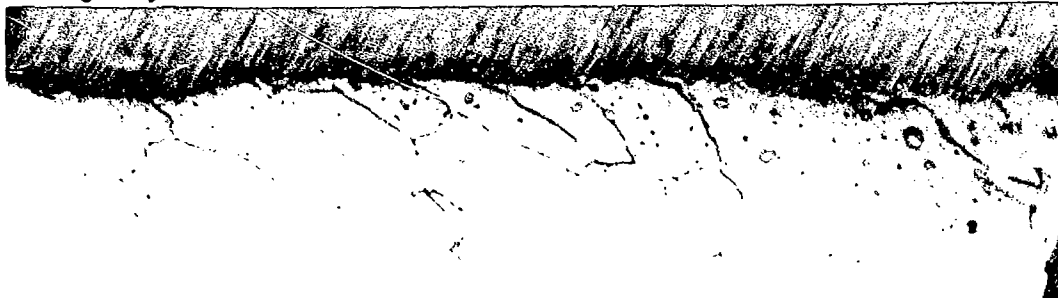
Electrofilm 2007 on Hastalloy X

Figure 61

Mag: 250X

1000°F

Etch: C



M 4616

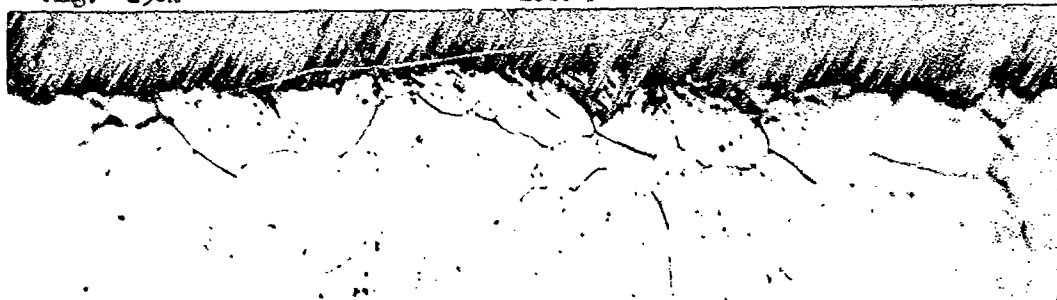
Electrofilm 2007 on 310 SS

Figure 62

Mag: 250X

1000°F

Etch: D



M 4617

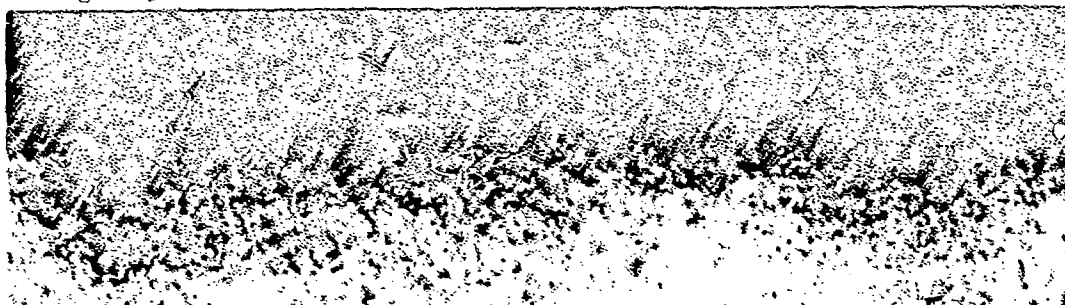
Electrofilm 2007 on 4130 Steel

Figure 63

Mag: 250X

1000°F

Etch: S



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M 4618

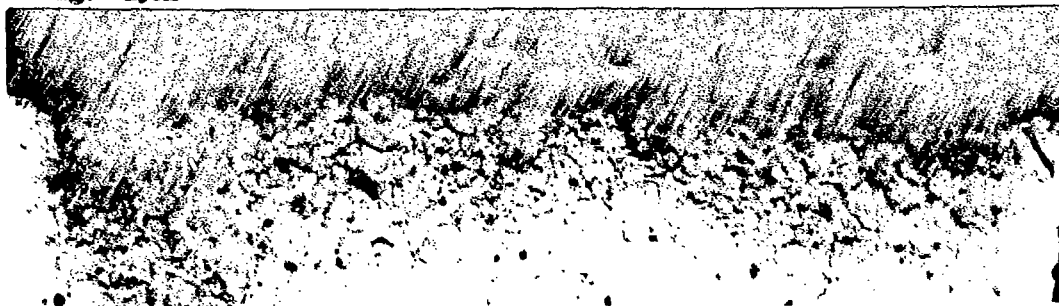
Electrofilm 66C on Inconel X

Figure 64

Mag: 250X

1000°F

Etch: A



M 4619

Electrofilm 66C on A-286

Figure 65

Mag: 250X

1000°F

Etch: B



M 4620

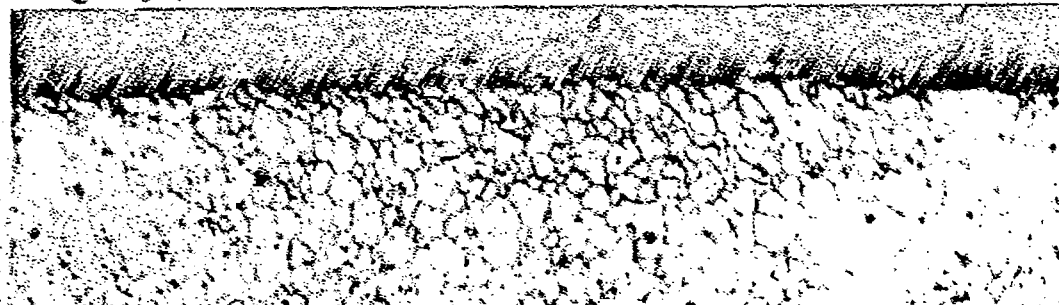
Electrofilm 66C on Hastelloy

Figure 66

Mag: 250X

1000°F

Etch: C



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N 4621

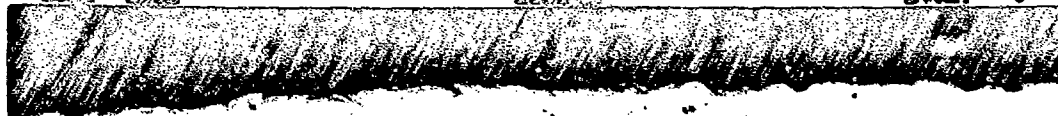
Electrofilm 66C on L-605

Figure 67

Mag: 250X

1000°F

Stch: C



N 4622

Electrofilm 66C on Bastalloy X

Figure 68

Mag: 250X

1000°F

Stch: C



N 4623

Electrofilm 66C on 310 SS

Figure 69

Mag: 250X

1000°F

Stch: D



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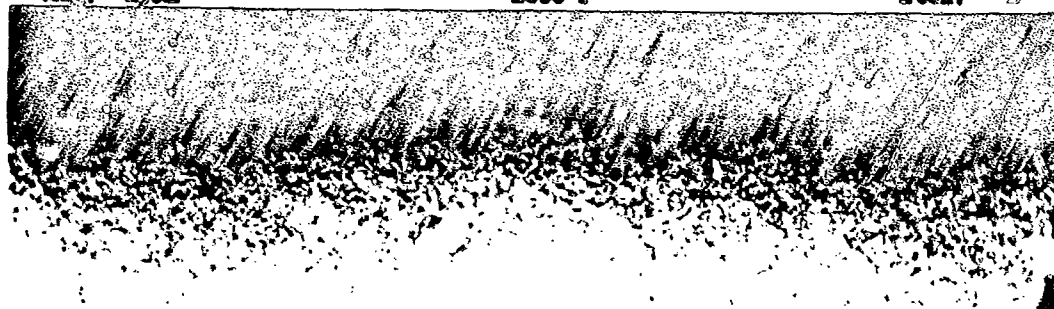
REVISION DAE-21332

M 4624

Electrofilm 660 on 4130 Steel
1000°F

Figure 70
Etch: R

Magn: 250X



M 4625

Phosphatherm RM on Inconel X
1000°F

Figure 71
Etch: A

Magn: 250X

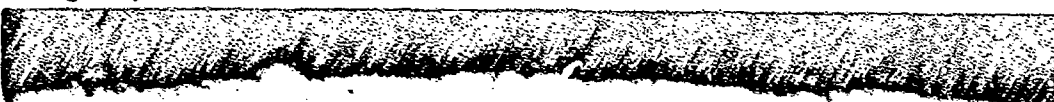


M 4626

Phosphatherm RM on A-286
1000°F

Figure 72
Etch: B

Magn: 250X



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N 4627

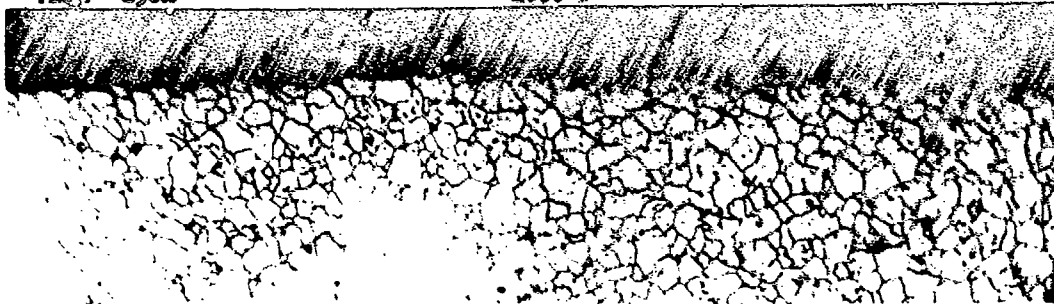
Phosphatarn RM on Pass 41

Figure 73

Mag: 250X

1000°

Etch: C



N 4628

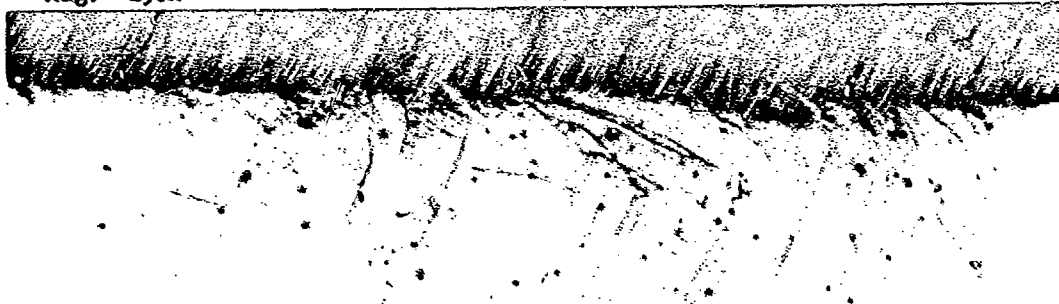
Phosphatarn RM on L-605

Figure 74

Mag: 250X

1000°

Etch: C



N 4629

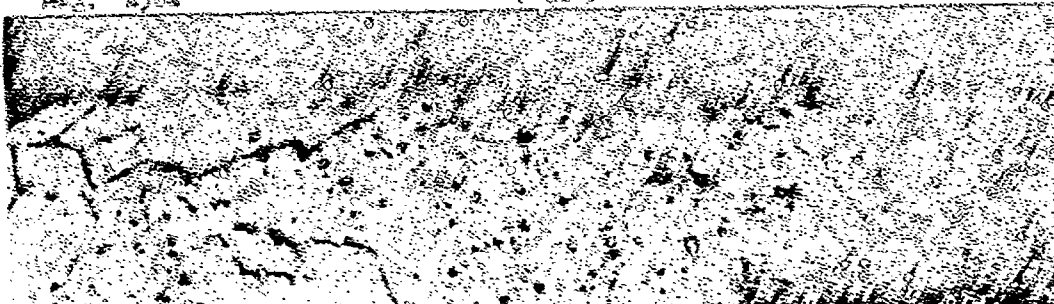
Phosphatarn RM on Westallay X

Figure 75

Mag: 250X

1000°

Etch: C



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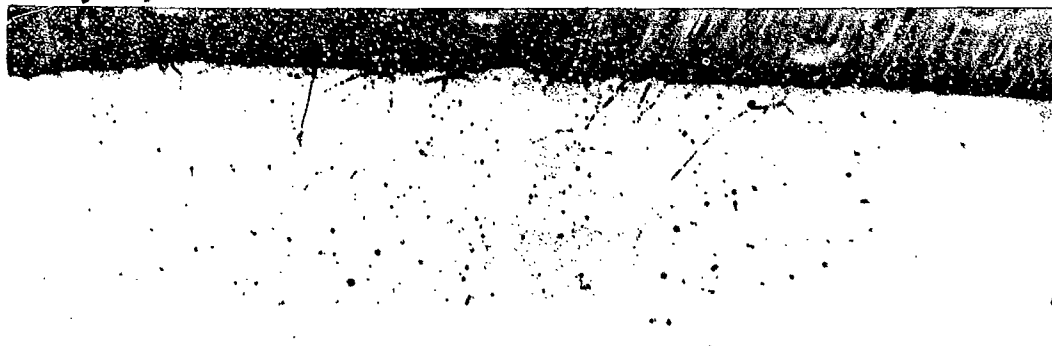
ST. LOUIS 66, MISSOURI

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M 4630

Phosphatherm RM on 310 SS
1000°F

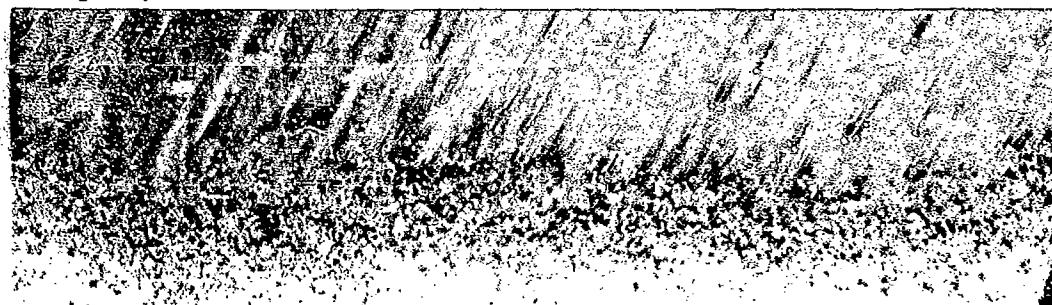
Figure 76
Etch: D



M 4631

Phosphatherm RM on 4130 Steel
1000°F

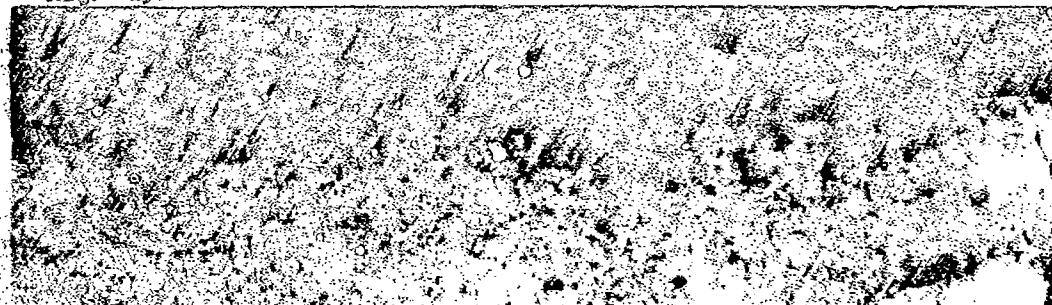
Figure 77
Etch: E



M 4632

Molykote X-10GM on Inconel X
1000°F

Figure 78
Etch: A



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M 4633

Molykote X-106M on A-286

Figure 79

Mag: 250X

1000°F

Etch: B



M 4634

Molykote X-106M on René 41

Figure 80

Mag: 250X

1000°F

Etch: C



M 4635

Molykote X-106M on L-605

Figure 81

Mag: 250X

1000°F

Etch: C



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N 4636

Molykote X-1064 on Hastalloy X
1000°F

Figure 82
Etch: C

Mag: 250X

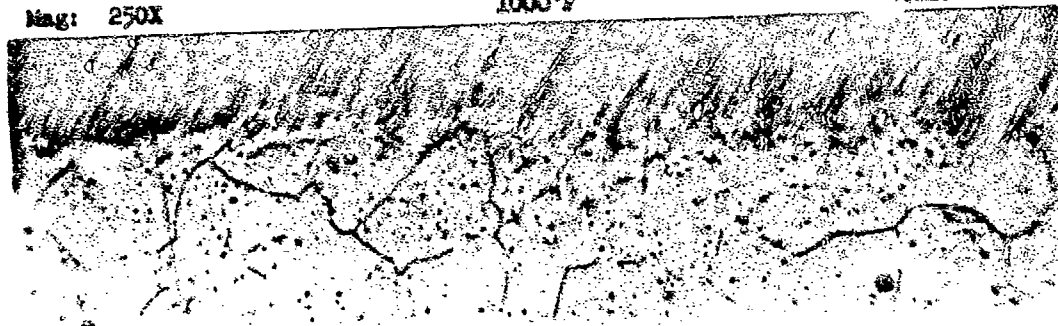


N 4637

Molykote X-1064 on 310 SS
1000°F

Figure 83
Etch: D

Mag: 250X

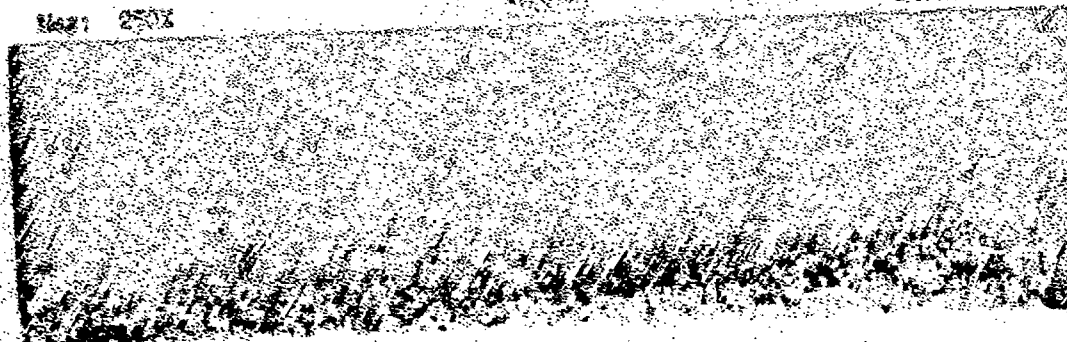


N 4638

Molykote X-1064 on 310 SS
1000°F

Figure 84
Etch: E

Mag: 250X



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M 4639

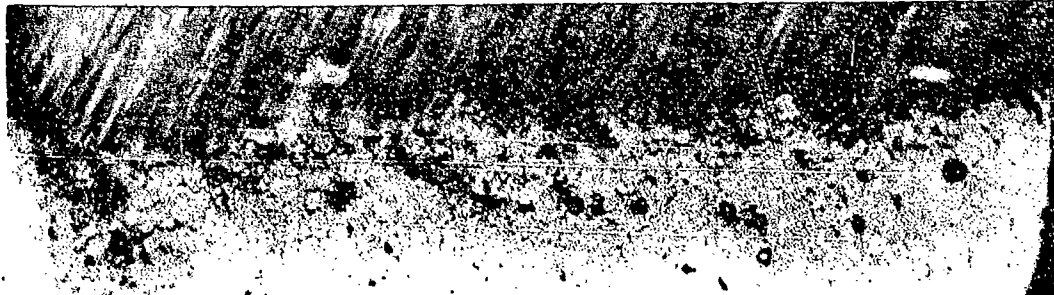
Sodium Silicate on Inconel X

Figure 85

Mag: 250X

1000°F

Etch: A



M 4640

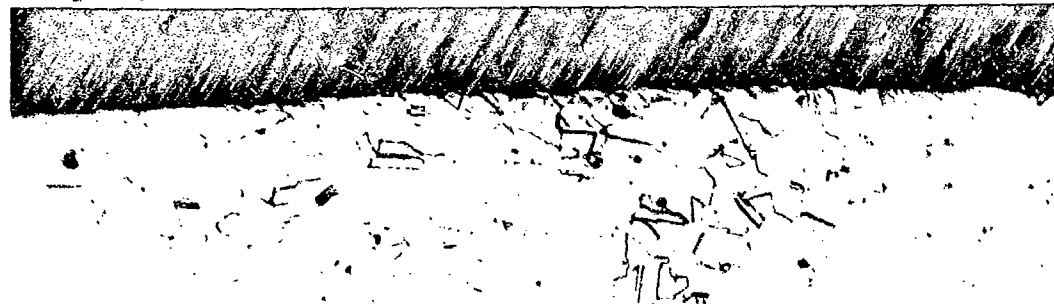
Sodium Silicate on A-286

Figure 86

Mag: 250X

1000°F

Etch: B



M 4641

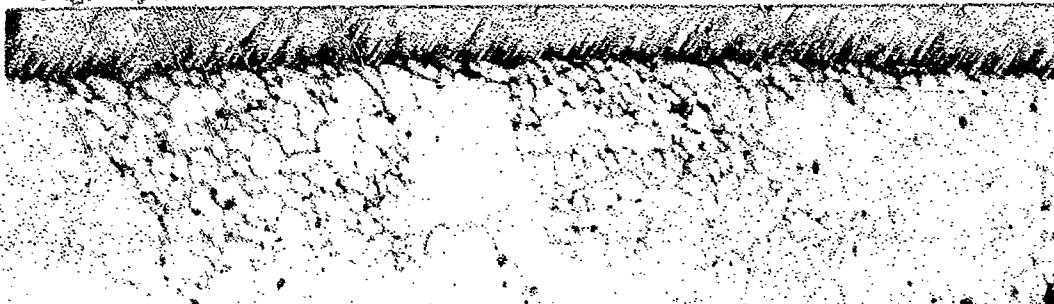
Sodium Silicate on Rene 41

Figure 87

Mag: 250X

1000°F

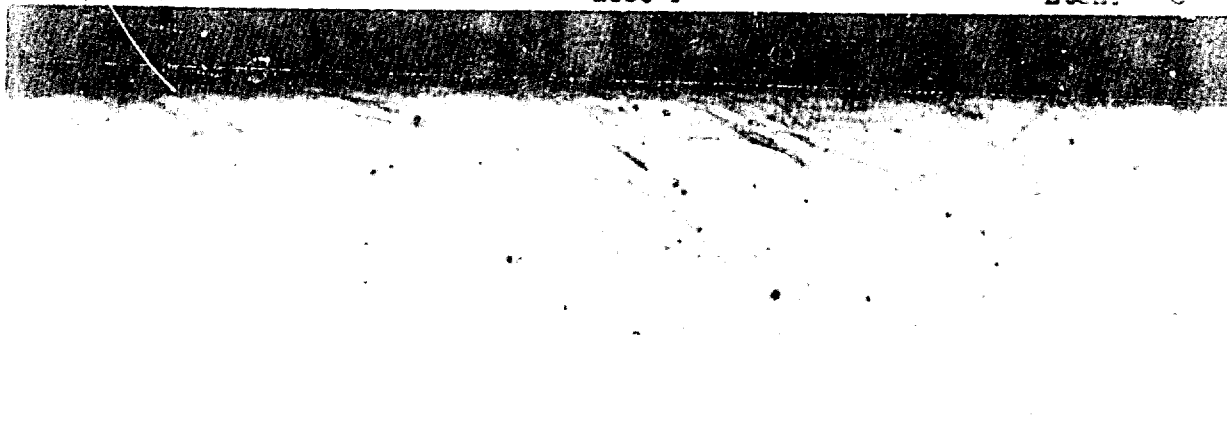
Etch: C



M 4642
Mag: 250X

Sodium Silicate on L-605
1000°F

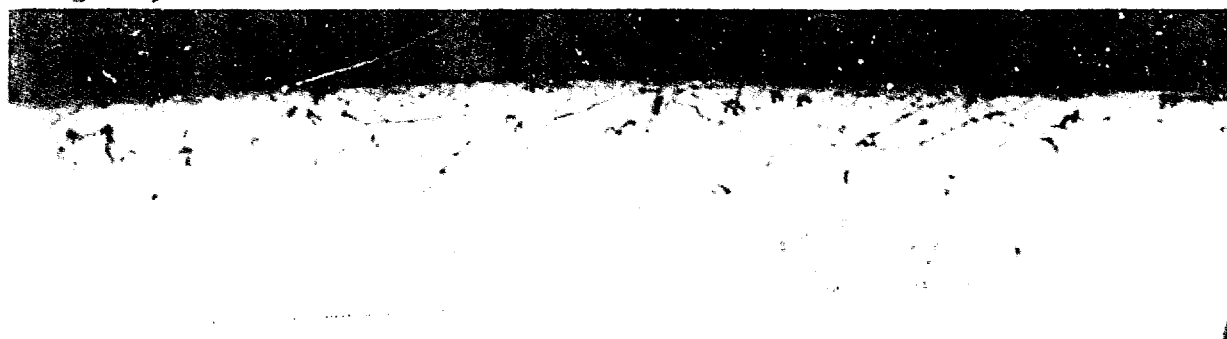
Figure 38
Etch: C



M 4643
Mag: 250X

Sodium Silicate on Hastelloy X
1000°F

Figure 39
Etch: C



M 4644
Mag: 250 X

Sodium Silicate on 310 SS
1000°F

Figure 40
Etch: D



M 4645

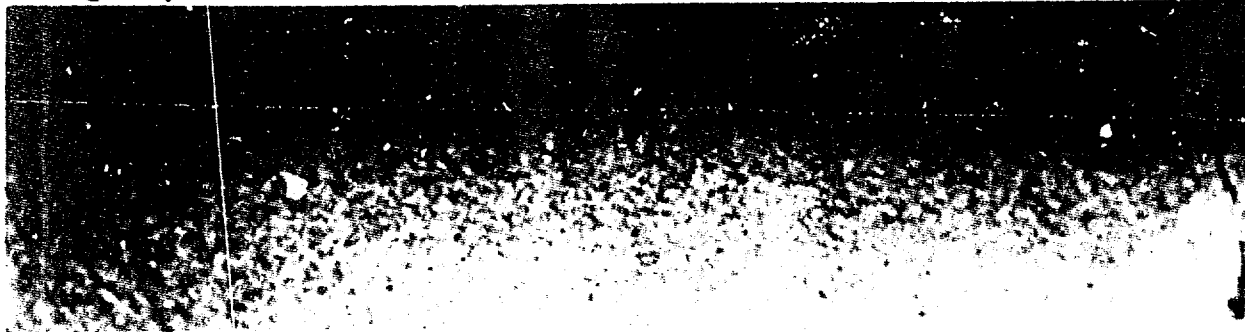
Mag: 250X

Sodium Silicate on 4130 Steel

1000°F

Figure 91

Etch: E



M 4646

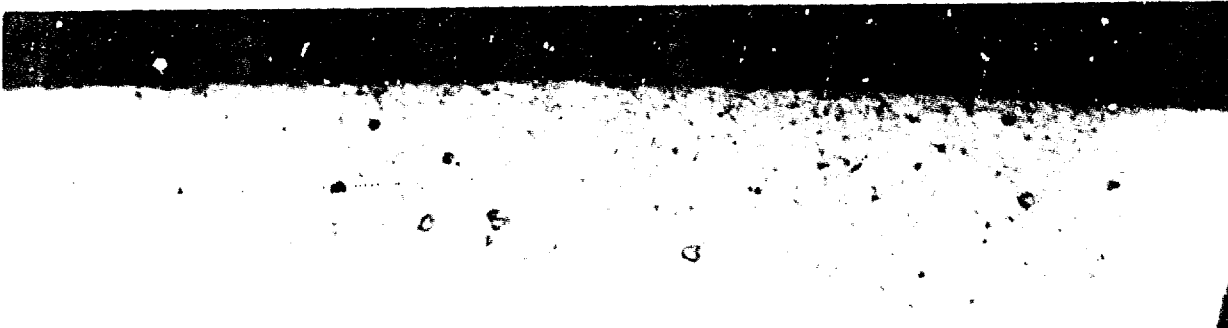
Mag: 250X

Silica on Inconel X

1000°F

Figure 92

Etch: A



M 4647

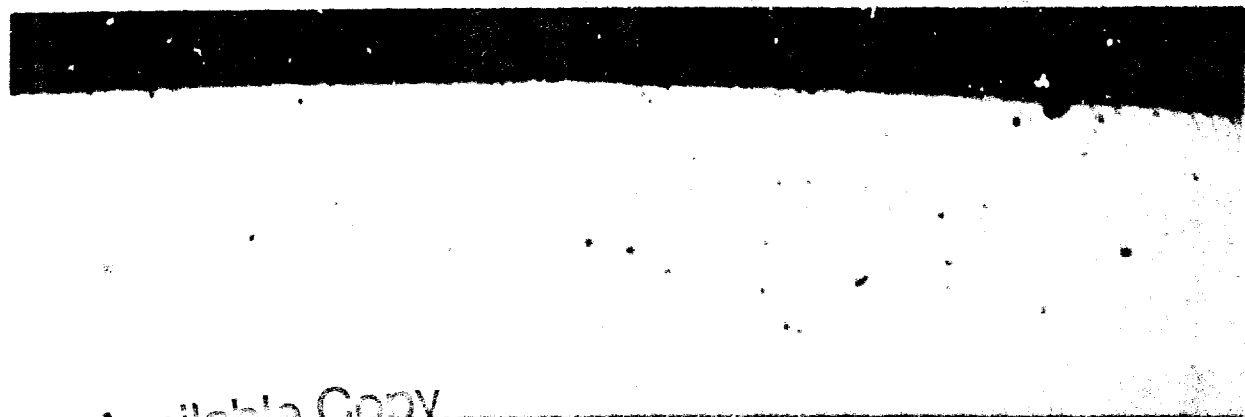
Mag: 250X

Silica on A-286

1000°F

Figure 93

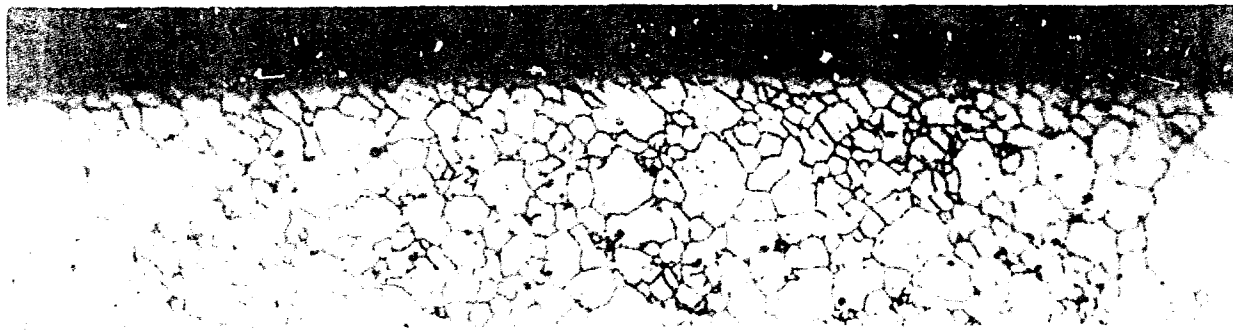
Etch: B



M 4649
Mag: 250X

Silica on Rene' 41
1000°F

Figure 94
Etch: C



M 4649
Mag: 250X

Silica on L-605
1000°F

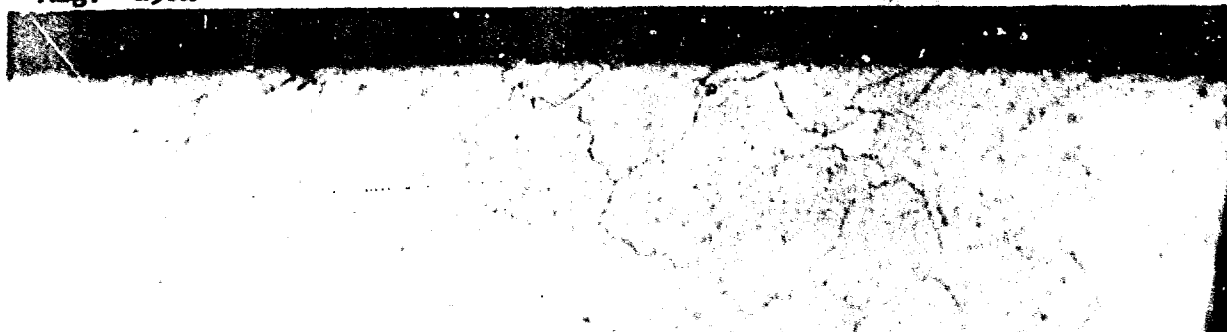
Figure 95
Etch: C



M 4650
Mag: 250X

Silica on Hastelloy X
1000°F

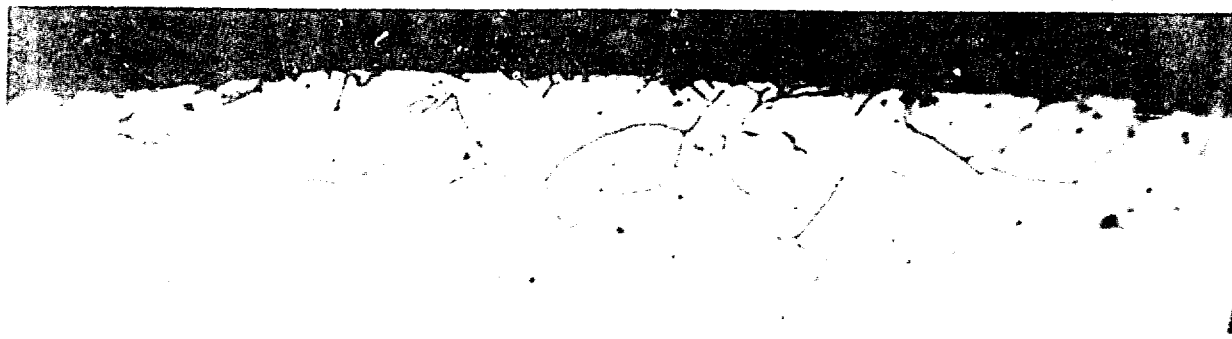
Figure 96
Etch: C



M 4651
Mag: 250X

Silica on 310 SS
1000°F

Figure 97
Etch: C



M 4652
Mag: 250X

Silica on 4130 Steel
1000°F

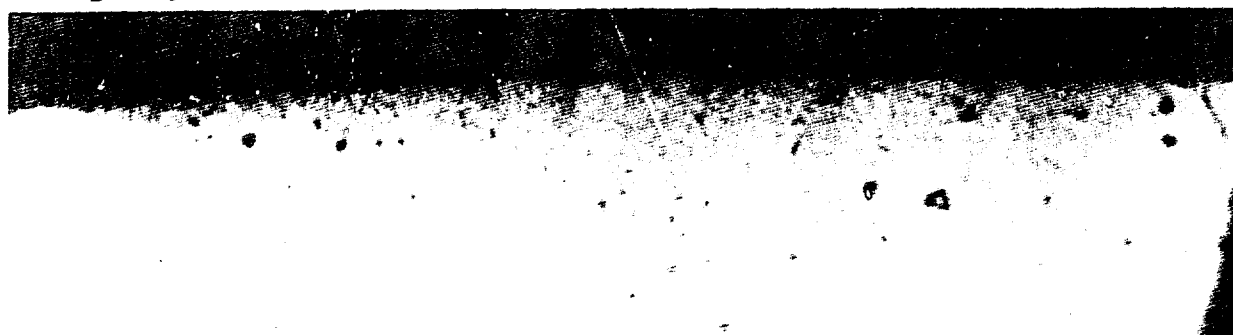
Figure 98
Etch: E



M 4653
Mag: 250X

Milk of Magnesia on Inconel X
1000°F

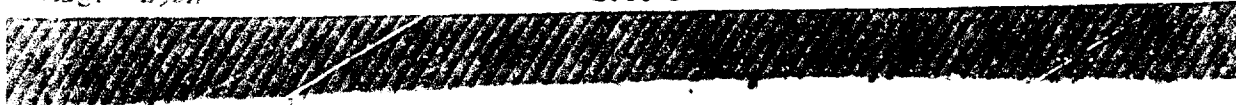
Figure 99
Etch: A



M 4655
Mag: 250X

Milk of Magnesia on A-286
1000°F

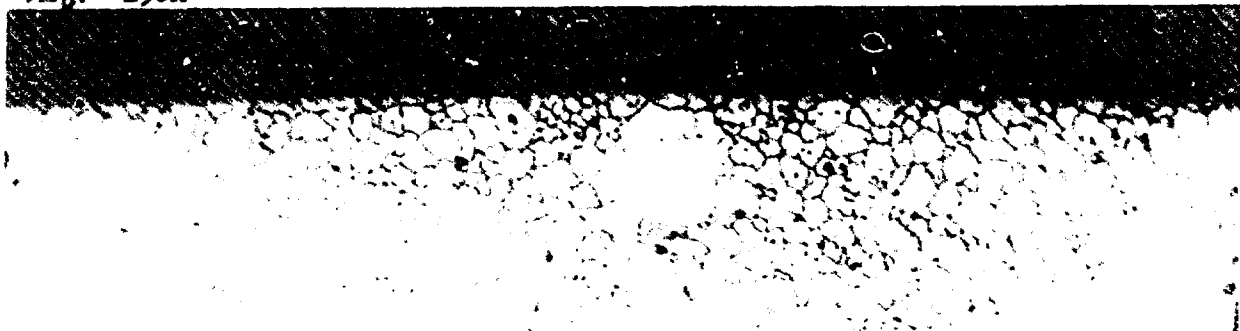
Figure 100
Etch: B



M 4655
Mag: 250X

Milk of Magnesia on Rene'41
1000°F

Figure 101
Etch: C



M 4655
Mag: 250X

Milk of Magnesia on L-605
1000°F

Figure 102
Etch:

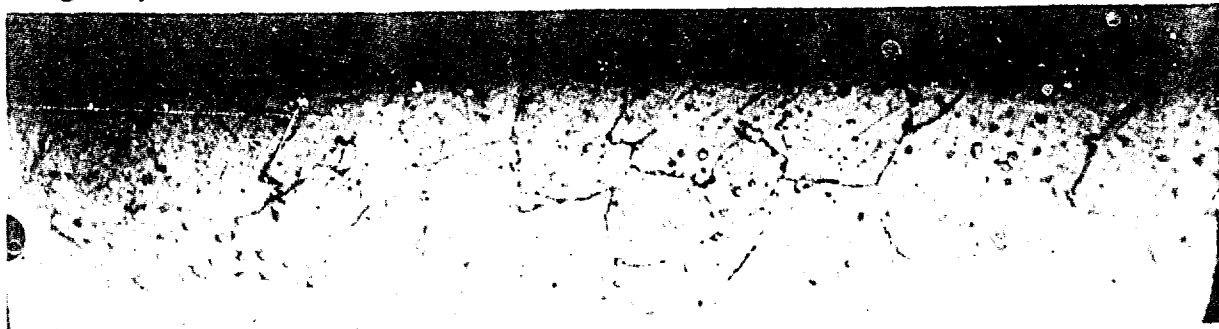


17-100 DMS-210045

M 4657
Mag: 250X

Milk of Magnesia on Hastelloy X
1000°F

Figure 103
Etch: C



M 4658
Mag: 250 X

Milk of Magnesia on 310 SS
1000°F

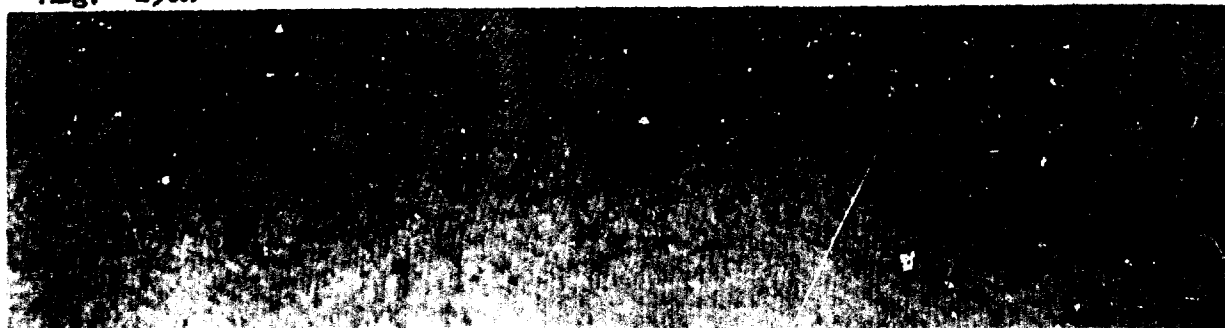
Figure 104
Etch: D



M 4659
Mag: 250X

Milk of Magnesia on 4130 Steel
1000°F

Figure 105
Etch: E



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Figure 106

Magnesium Oxide on Inconel X

Figure 106

Mag: 250X

1000°F

Etch: A

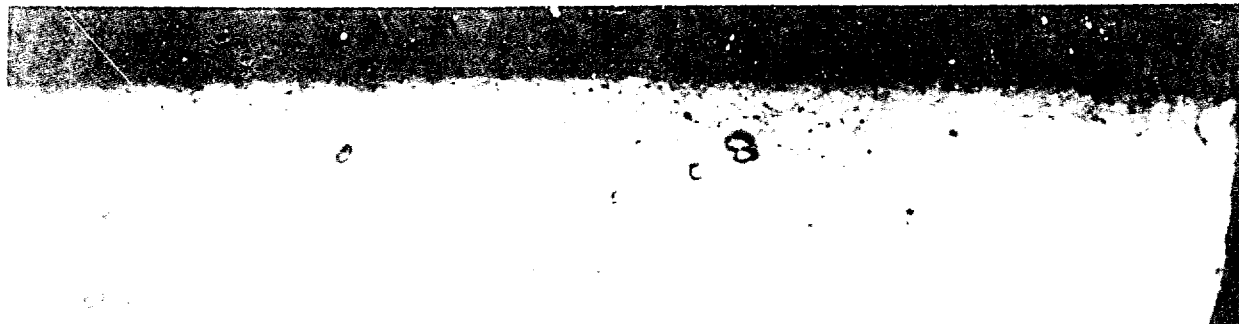


Figure 107

Magnesium Oxide on A-286

Figure 107

Mag: 250X

1000°F

Etch: B



Figure 108

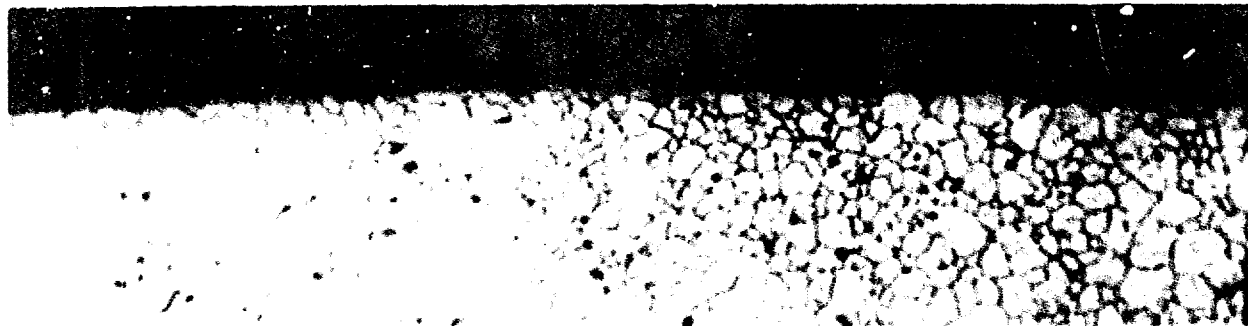
Magnesium Oxide on Rene'41

Figure 108

Mag: 250X

1000°F

Etch: C



100-11115

M 4603

Magnesium Oxide on L-605

Figure 110

Mag: 250X

1000°F

Etch: C



M 4664

Magnesium Oxide on Hastelloy X

Figure 111

Mag: 250X

1000°F

Etch: C



M 4665

Magnesium Oxide on 310 SS

Figure 112

Mag: 250X

1000°F

Etch: D



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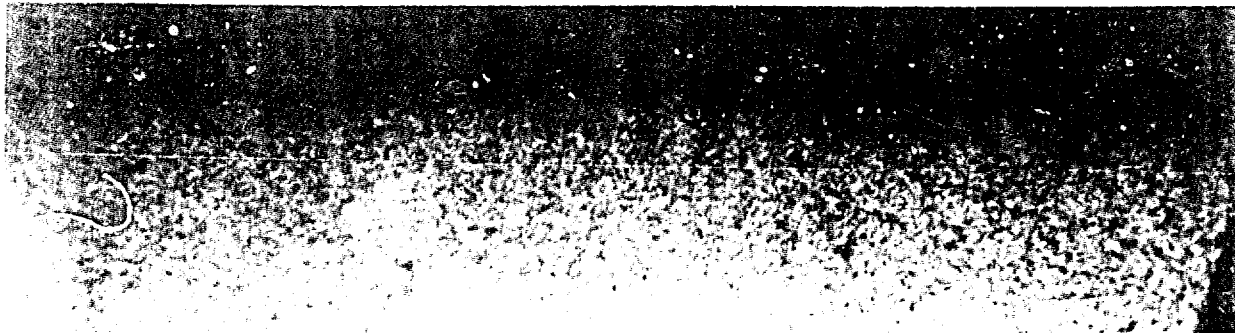
M 4666

Mag: 250X

Magnesium Oxide on 4130 Steel
1000°F

Figure 112

Etch: E



M 4667

Mag: 250X

Boron Nitride on Inconel X
1000°F

Figure 113

Etch: A



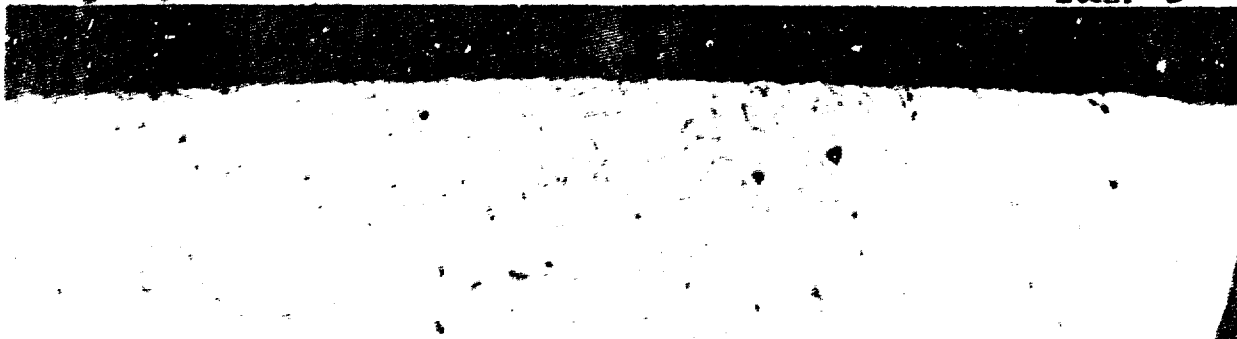
M 4668

Mag: 250X

Boron Nitride on A-286
1000°F

Figure 114

Etch: B



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M 4669

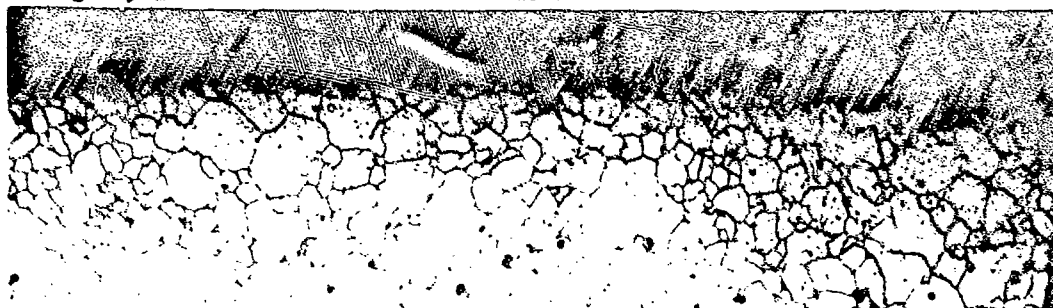
Boron Nitride on Rene '41

Figure 115

Mag: 250X

1000°F

Etch: C



M 4670

Boron Nitride on L-605

Figure 116

Mag: 250X

1000°F

Etch: C



M 4671

Boron Nitride on Hastelloy X

Figure 117

Mag: 250X

1000°F

Etch: C



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M 4672

Boron Nitride on 310 SS

Figure 118

Mag: 250X

1000°F

Etch: D



M 4673

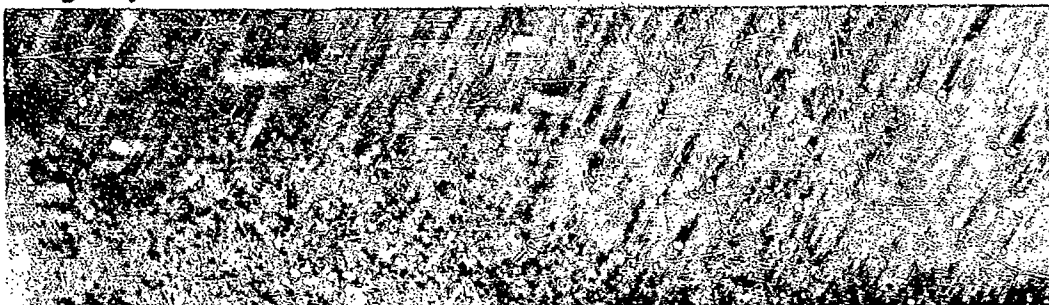
Boron Nitride on 4130 Steel

Figure 119

Mag: 250X

1000°F

Etch: E



M 4674

Boric Oxide on Inconel X

Figure 120

Mag: 250X

1000°F

Etch: A



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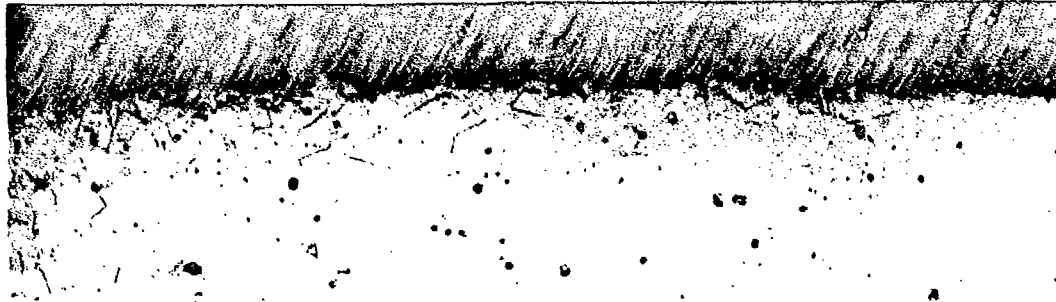
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M 4675
Mag: 250X

Boric Oxide on A-286
1000°F

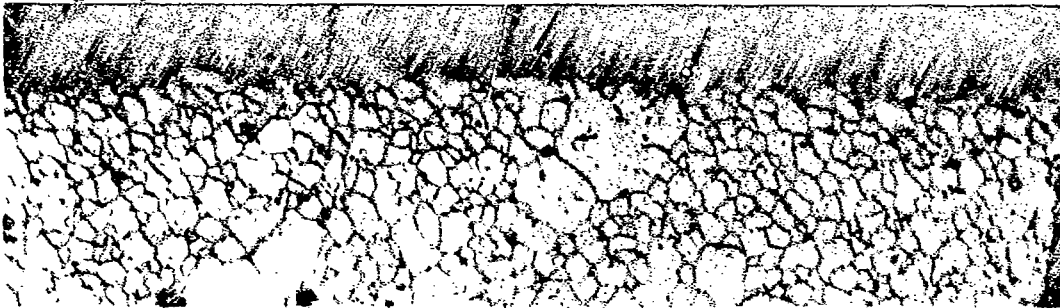
Figure 121
Etch: B



M 4676
Mag: 250X

Boric Oxide on Rene '41
1000°F

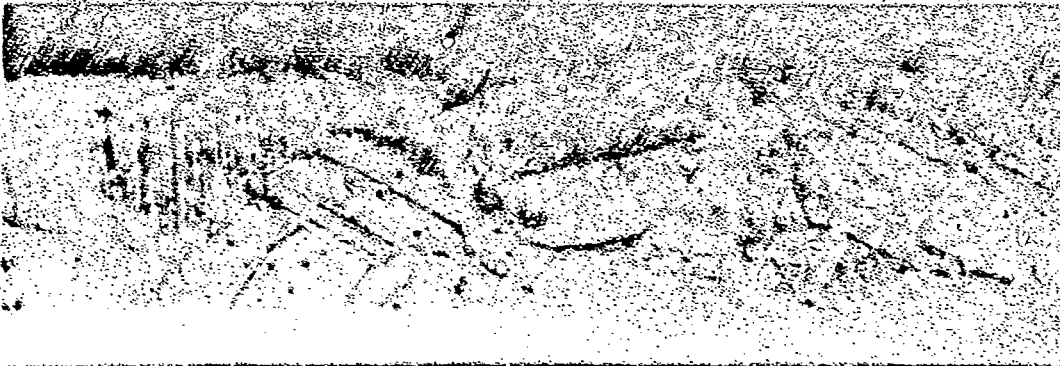
Figure 122
Etch: C



M 4677
Mag: 250X

Boric Oxide on L-605
1000°F

Figure 123
Etch: C



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N 4681

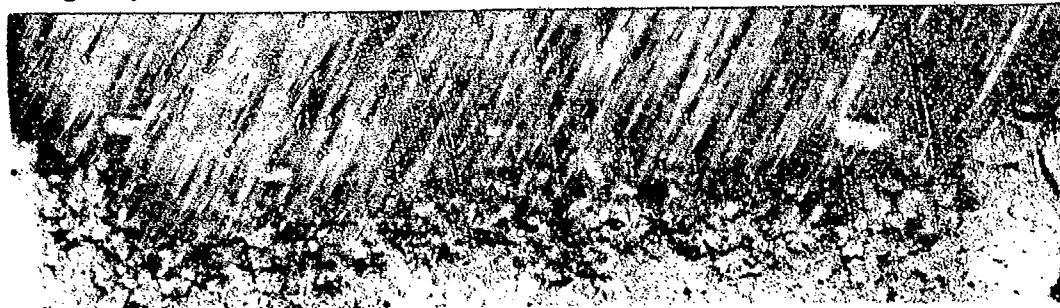
MOLYKOTE X-106 ON INCOSEL X

Figure 127

Mag: 250X

1000°F

Etch: A



N 4682

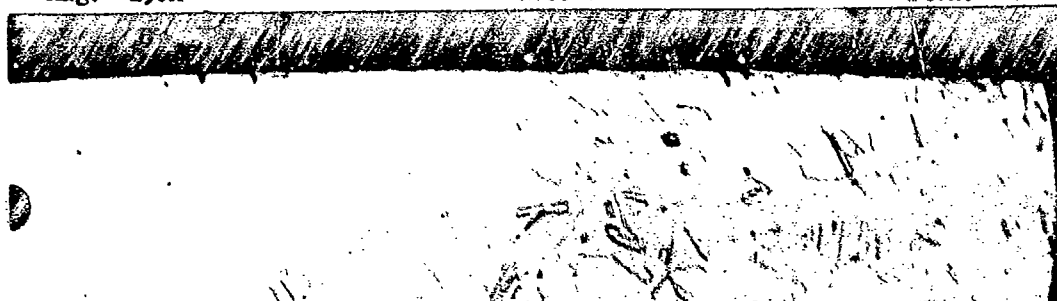
MOLYKOTE X-106 ON A-286

Figure 128

Mag: 250X

1000°F

Etch: B



N 4683

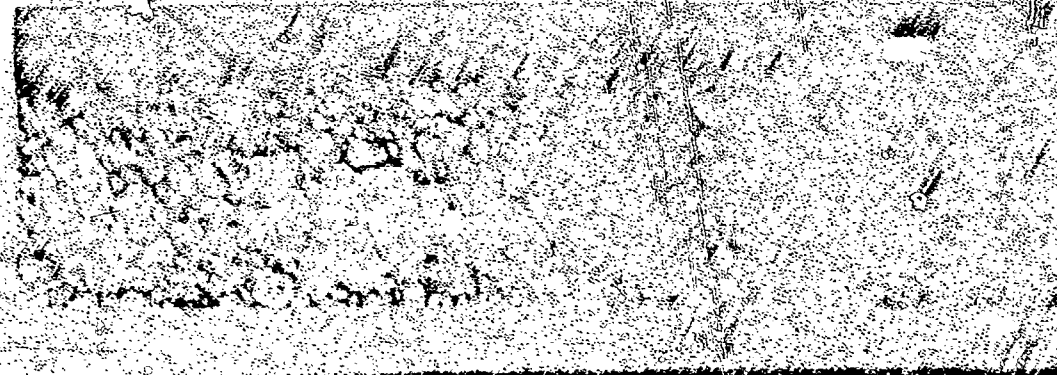
MOLYKOTE X-106 ON INCOSEL X

Figure 129

Mag: 250X

1000°F

Etch: C



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M 4684

MOLYBDE X-106 ON L-605

Figure 130

Mag: 250X

1000°F

Etch: C



M 4685

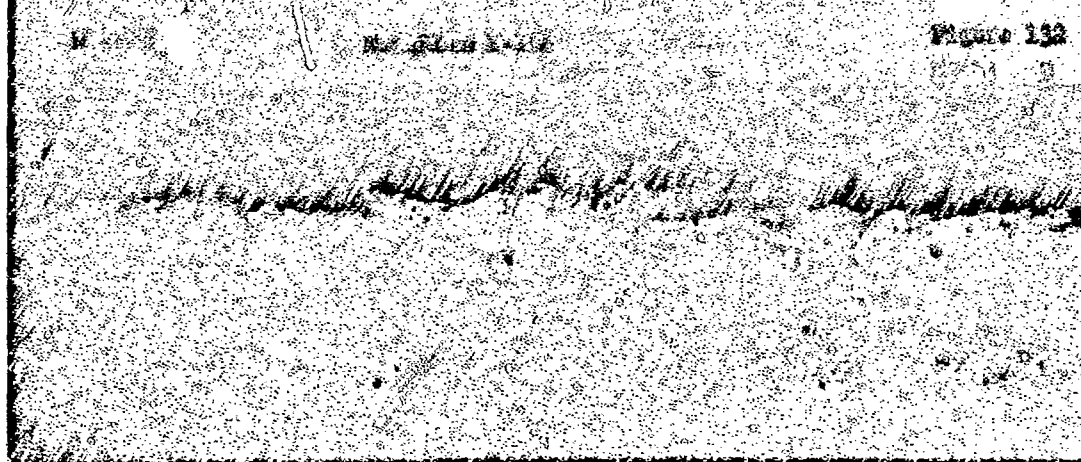
MOLYBDE X-106 ON HASTELLOY X

Figure 131

Mag: 250 X

1000°F

Etch: C



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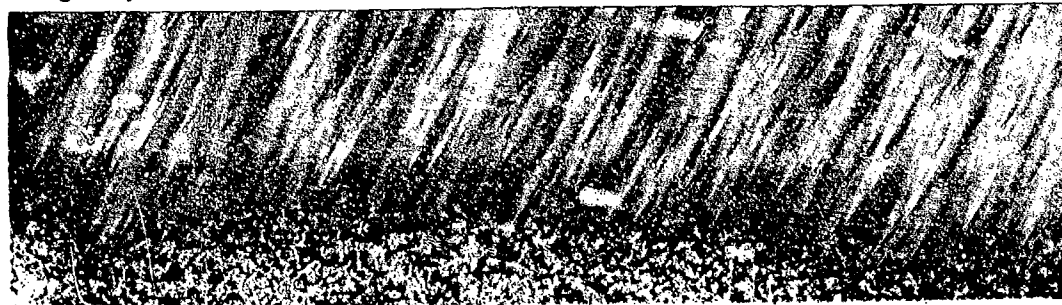
M 4687

Molykote X-10t On 4130
1000°F

Figure 133

Mag: 250X

Etch: E



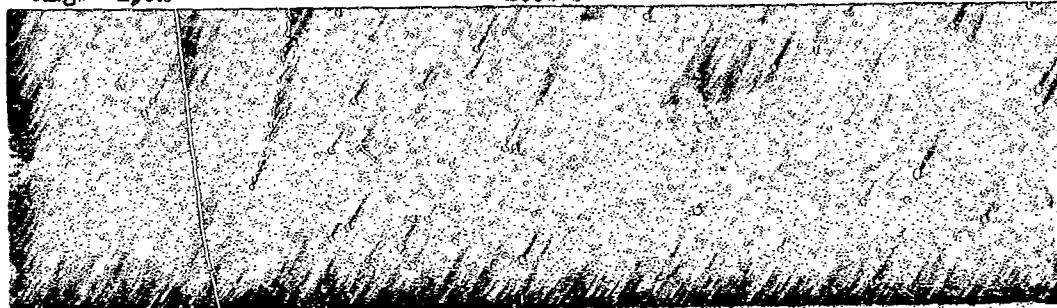
M 4688

Lead Monoxide on Inconel X
1000°F

Figure 134

Mag: 250X

Etch: A



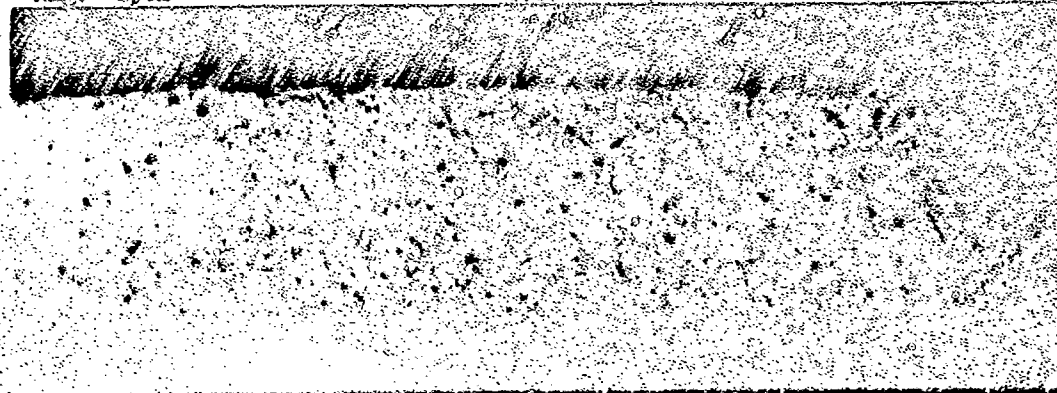
M 4689

Lead Monoxide on A-286
1000°F

Figure 135

Mag: 250X

Etch: B



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M 4690

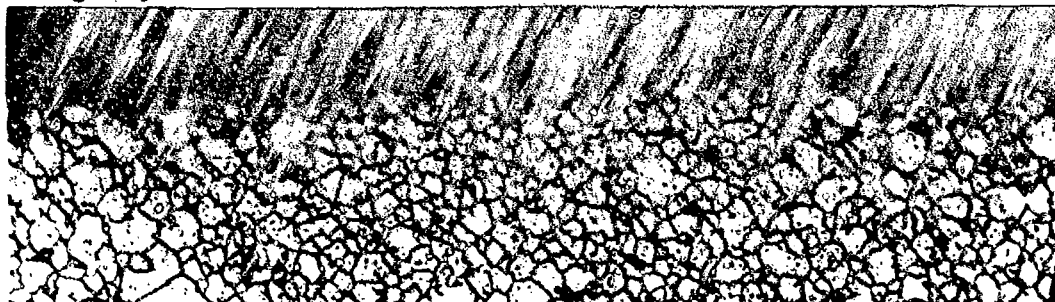
Lead Monoxide on Bess '41

Figure 136

Mag: 250X

1000°F

Etch: C



M 4691

Lead Monoxide on L-605

Figure 137

Mag: 250X

1000°F

Etch: C



M 4692

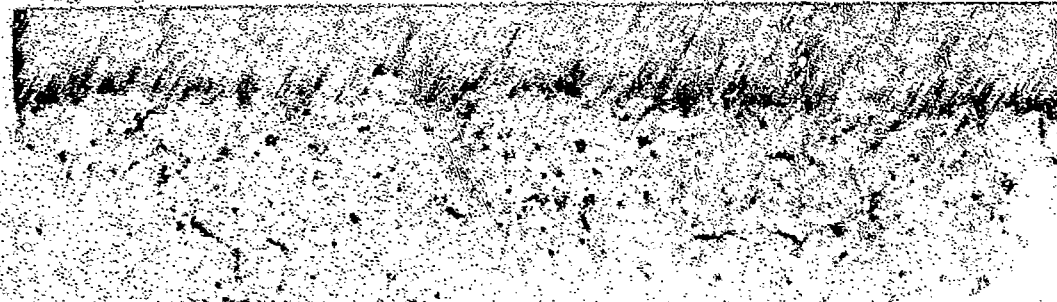
Lead Monoxide on Metalloy I

Figure 138

Mag: 250X

1000°F

Etch: C



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M 4693

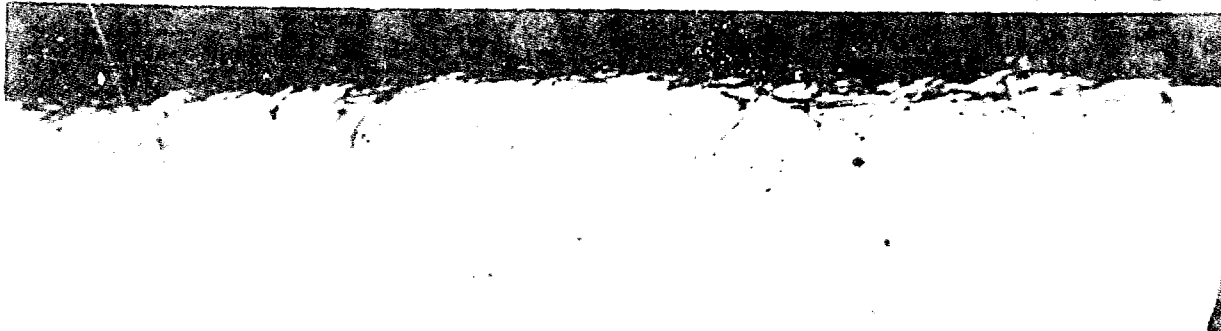
Lead Monoxide on 310 SS

Figure 1-0

Mag: 250X

1000°F

Etch: D



M 4694

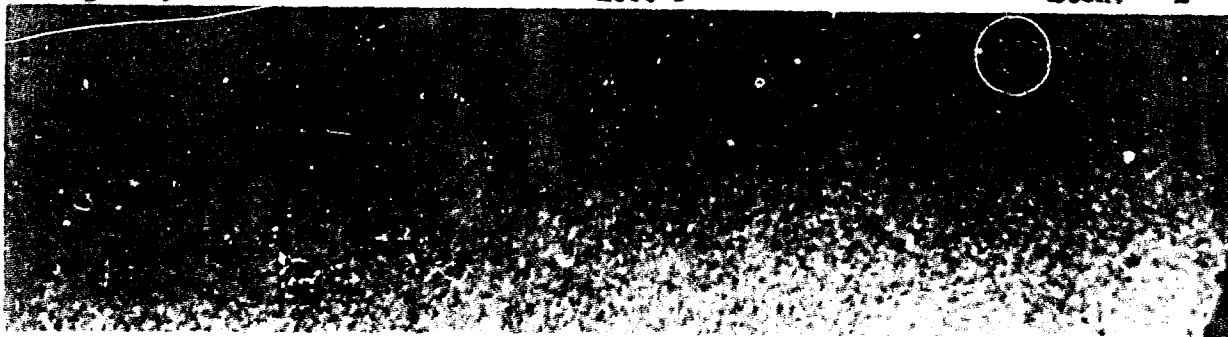
Lead Monoxide on 4130 Steel

Figure 1-0

Mag: 250X

1000°F

Etch: E



M 4695

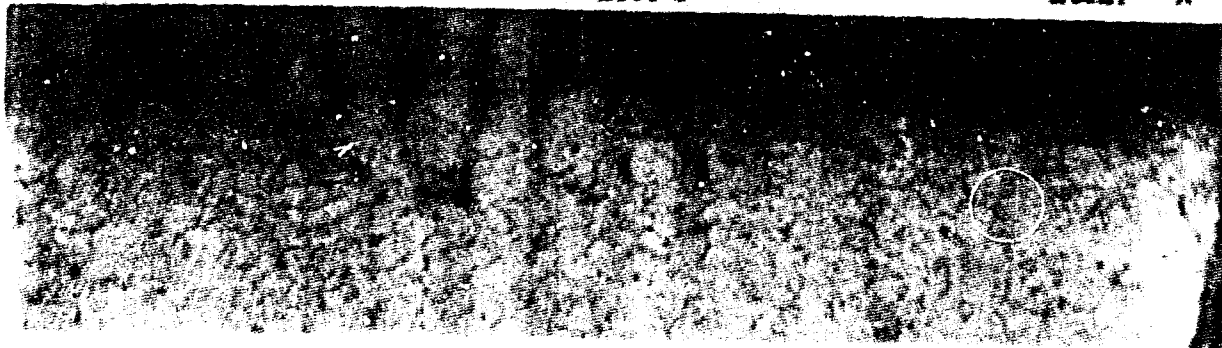
Calcium Fluoride on Inconel X

Figure 1-1

Mag: 250X

1000°F

Etch: A



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M 4696

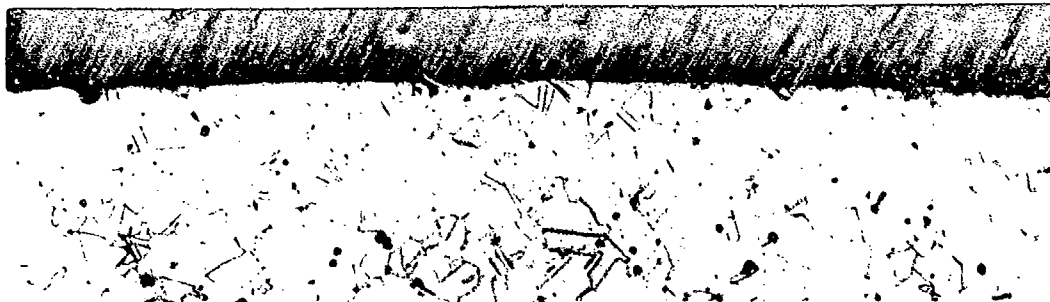
Calcium Fluoride on A-286

Figure 142

Mag: 250X

1000°F

Etch: B



M 4697

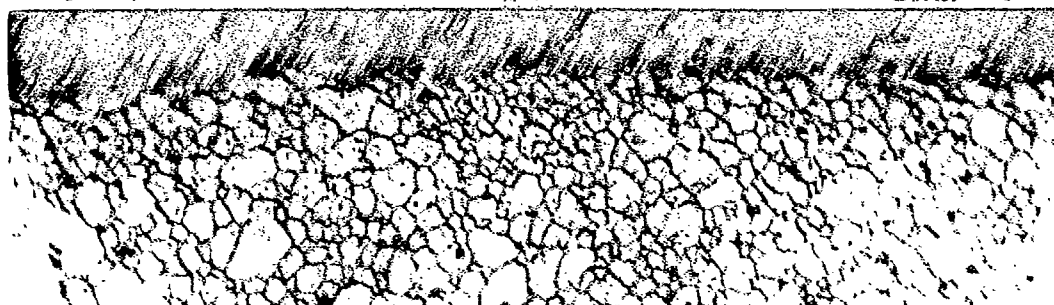
Calcium Fluoride on René 41

Figure 143

Mag: 250X

1000°F

Etch: C



M 4698

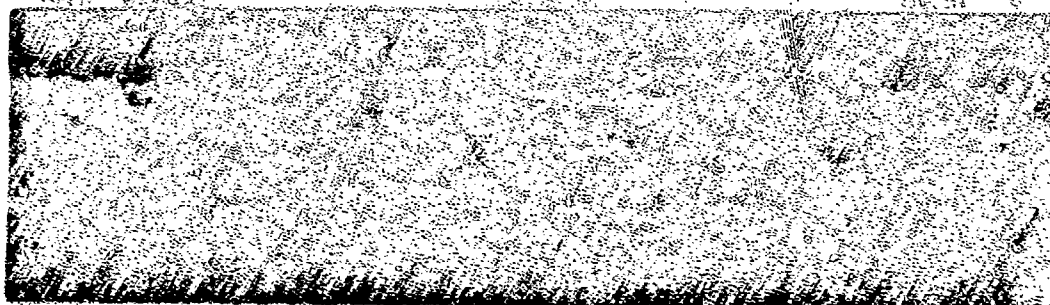
Calcium Fluoride on L-605

Figure 144

Mag: 250X

1000°F

Etch: C



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M 4699

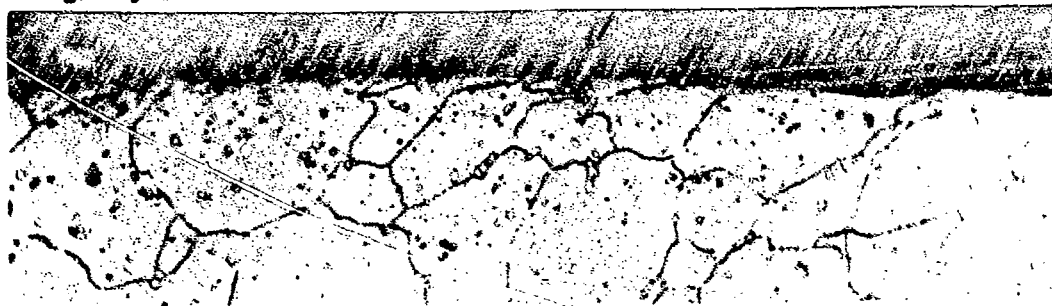
Calcium Fluoride on Hastelloy X

Figure 145

Mag: 250X

1000°F

Etch: C



M 4700

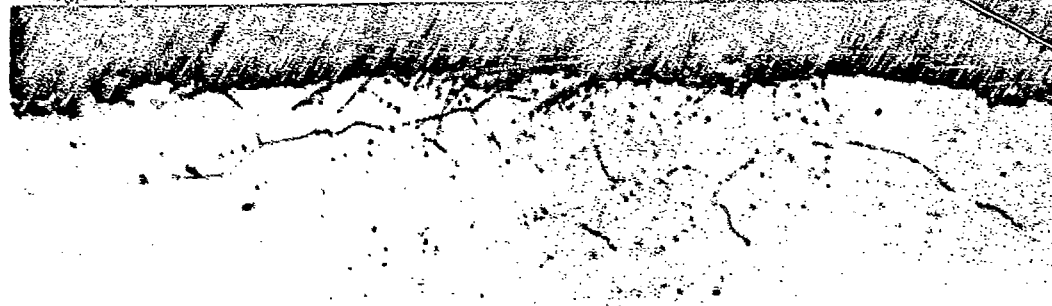
Calcium Fluoride on 316 SS

Figure 146

Mag: 250X

1000°F

Etch: D



M 4701

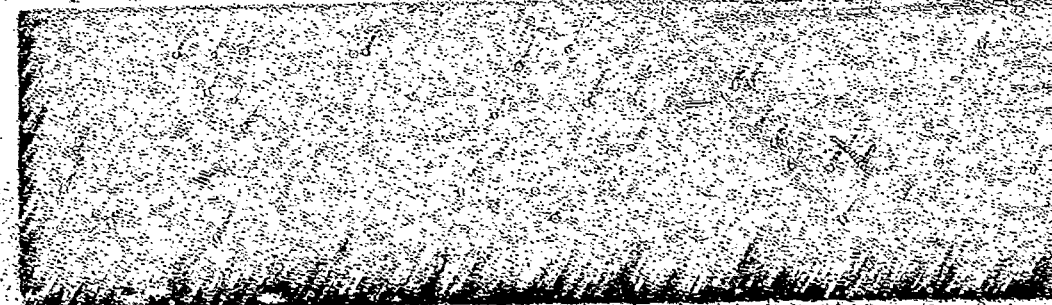
Calcium Fluoride on A19 Steel

Figure 147

Mag: 250X

1000°F

Etch: E



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M 4702

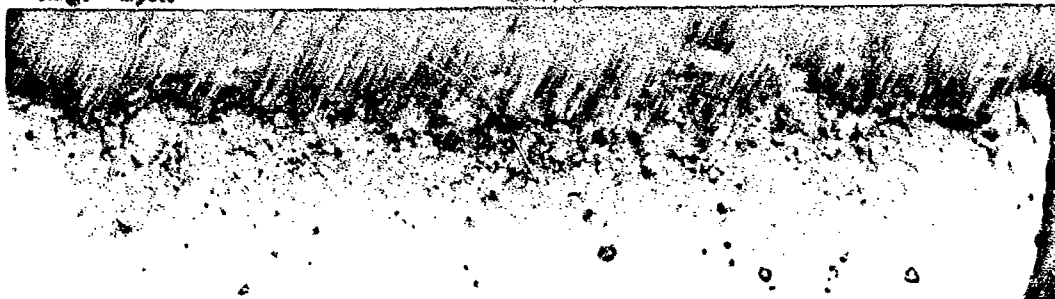
Lead Sulfide on Inconel X

Figure 148

Mag: 250X

1000°F

Etch: A



M 4703

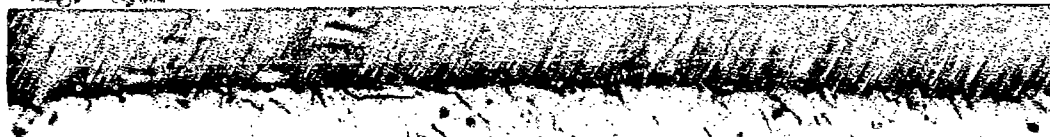
Lead Sulfide on A-336

Figure 149

Mag: 250X

1000°F

Etch: B



M 4704

Lead Sulfide on Lead 62

Figure 150

Mag: 250X

Etch: C



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M 4705

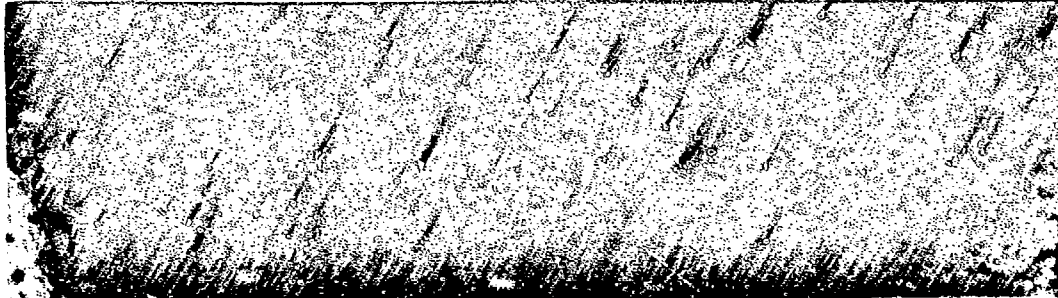
Lead Sulfide on L-605

Figure 151

Mag: 250X

1000²

Etch: C



M 4706

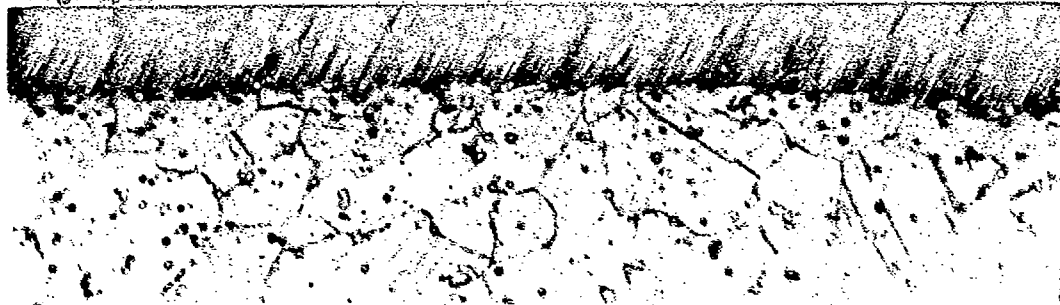
Lead Sulfide on Hastelloy X

Figure 152

Mag: 250X

1000²

Etch: C



M 4707

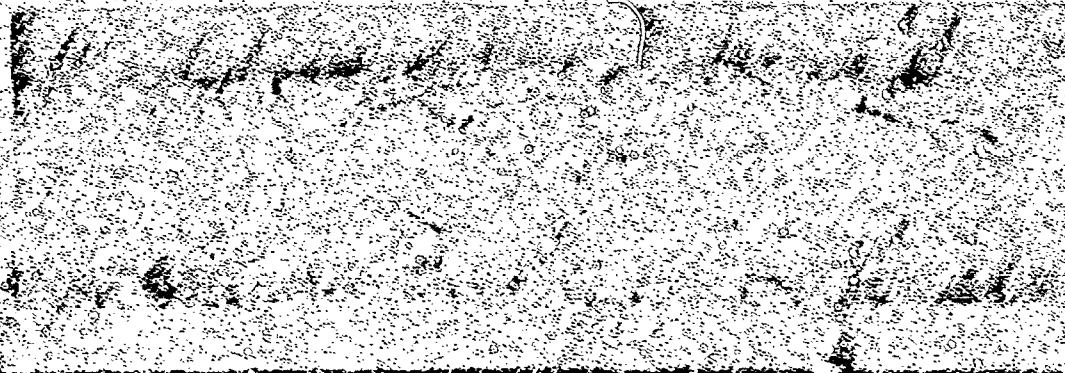
Lead Sulfide on 310 SS

Figure 153

Mag: 250X

1000²

Etch: C



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M 4708

Lead Sulfide on 4130 Steel

Figure 154

Mag: 250X

1000°F

Etch: E



M 4709

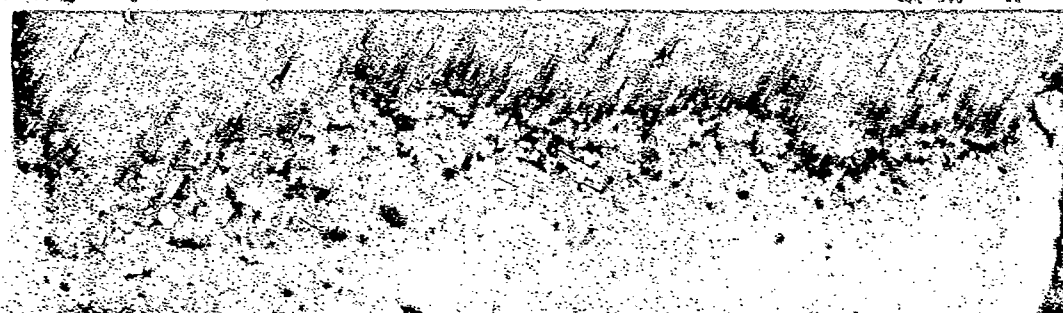
Inconel X in Air

Figure 155

Mag: 250X

1000°F

Etch: A



(Control Specimen)

M 4710

1-200 in Air

Figure 156



(Control Specimen)

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M 4711

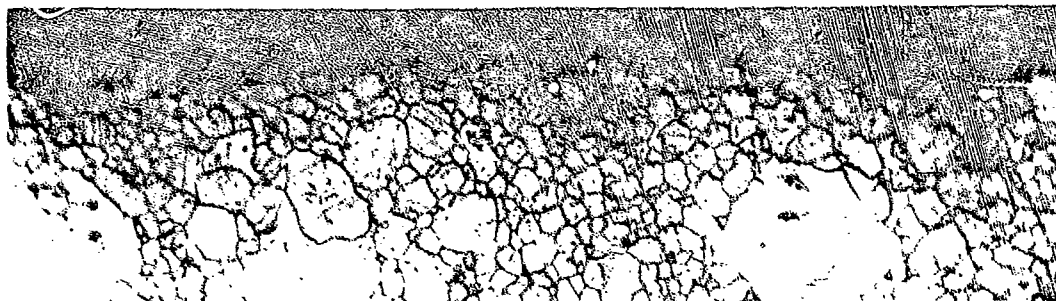
Reas' 41 in Air

Figure 157

Mag: 250X

1000°F

Etch: C



(Control Specimen)

M 4712

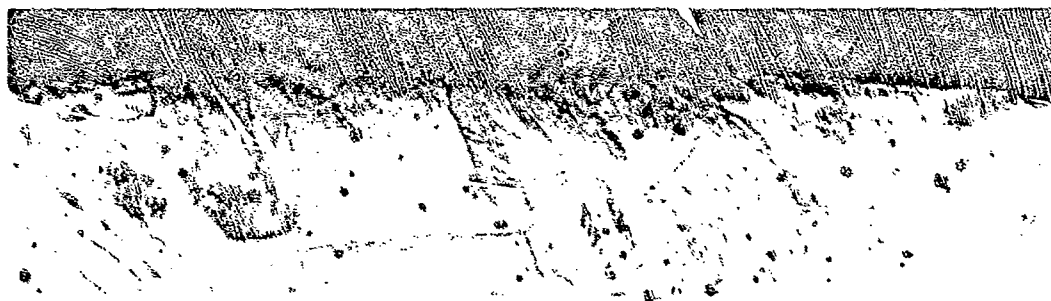
L-605 in Air

Figure 158

Mag: 250X

1000°F

Etch: C



(Control Specimen)

M 4713

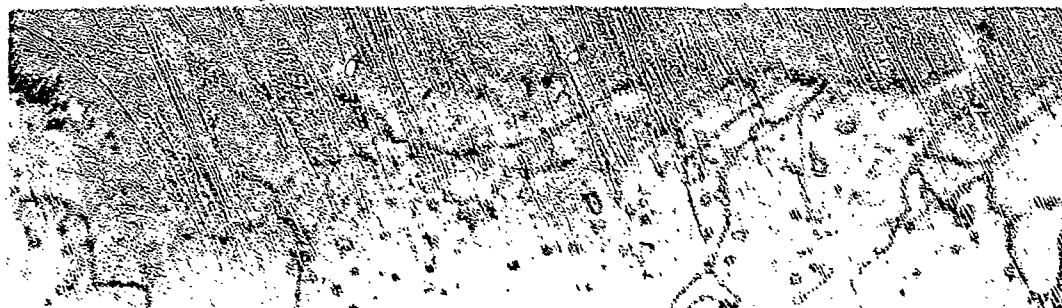
Reassembly in Air

Figure 159

Mag: 250X

1000°F

Etch: C



(Control Specimen)

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M 4714

310 SS in Air

Figure 160

Mag: 250X

1000°F

Etch: D



(Control Specimen)

M 4715

4130 Steel in Air

Figure 161

Mag: 250X

1000°F

Etch: E



(Control Specimen)

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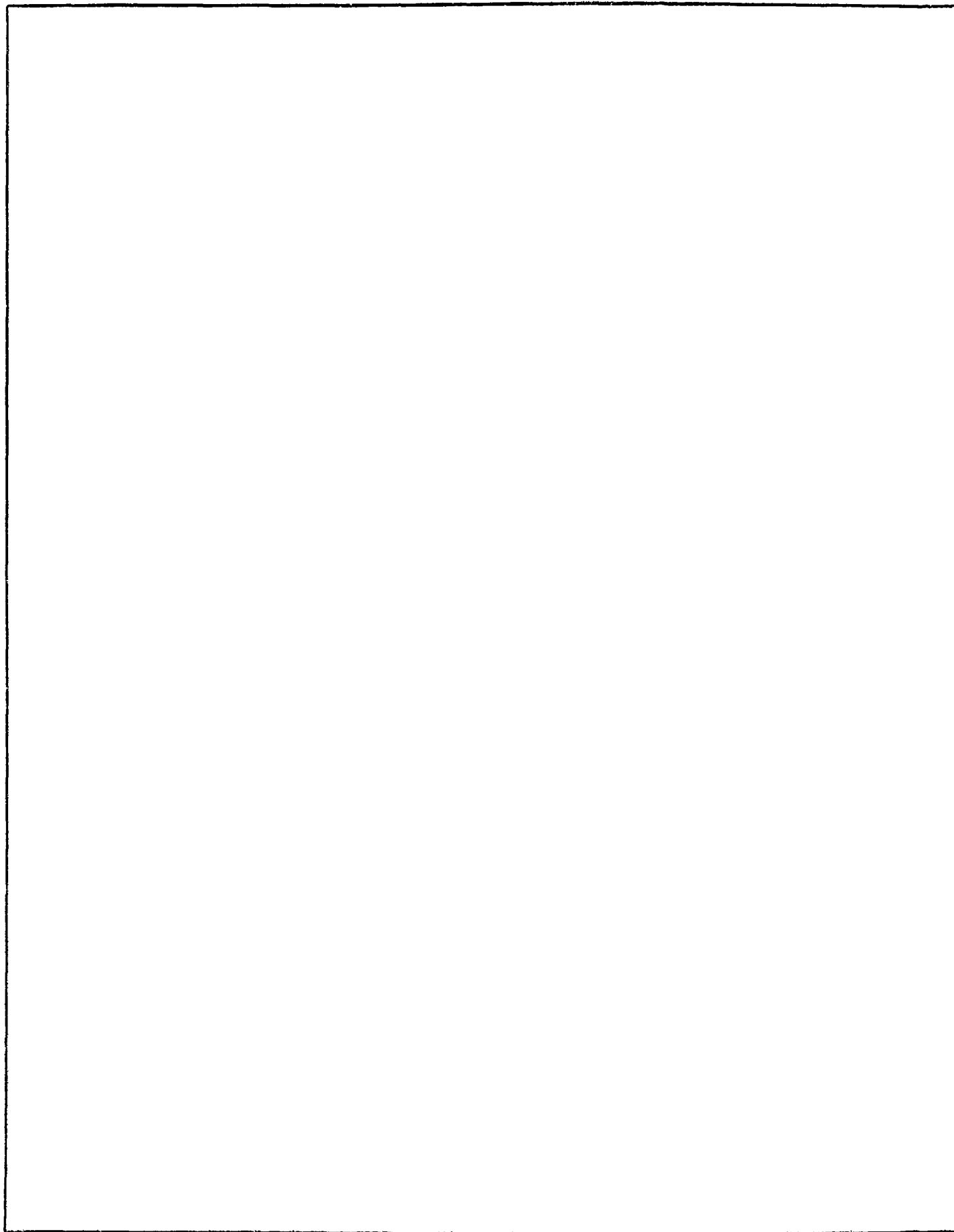
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ST. LOUIS.



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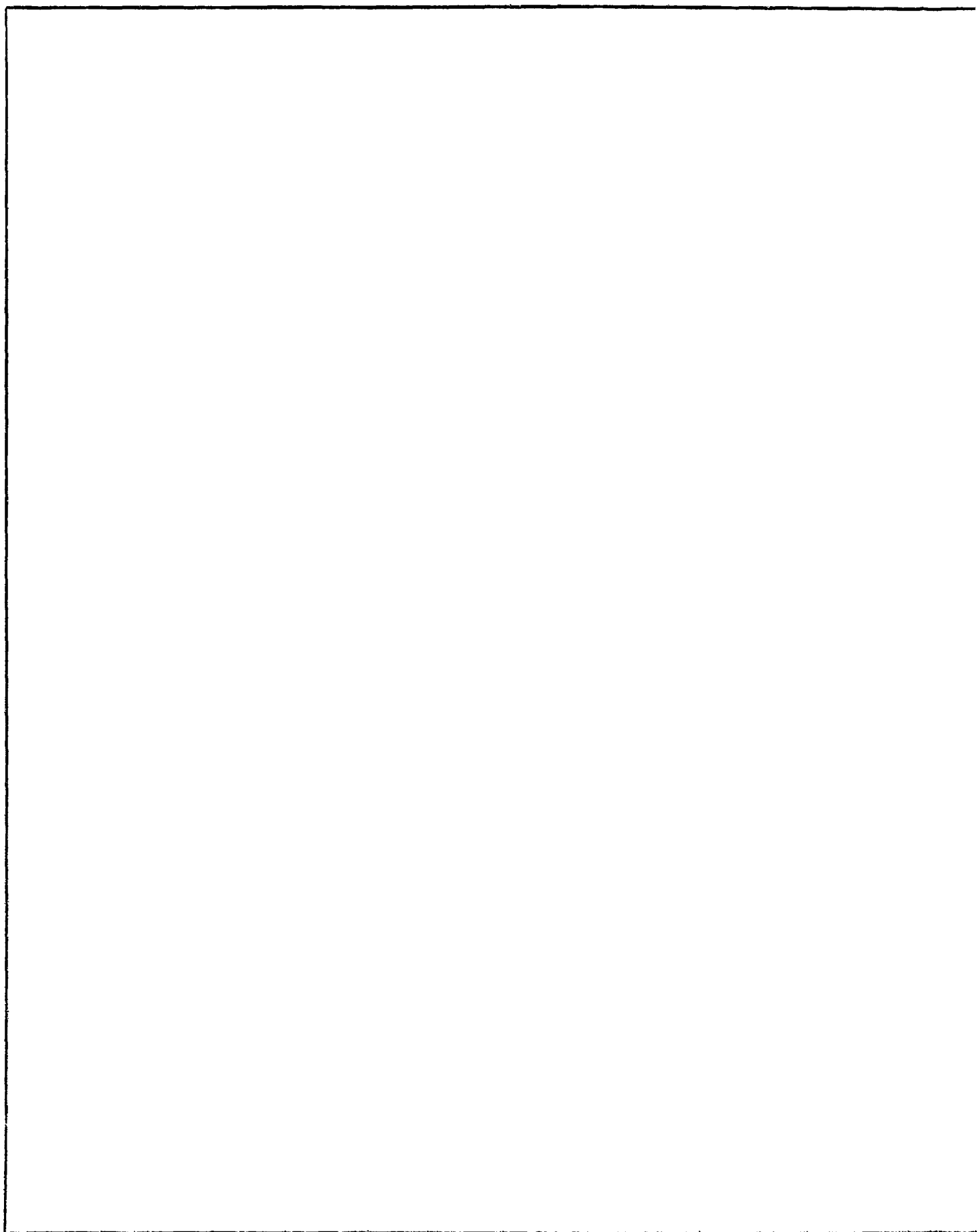
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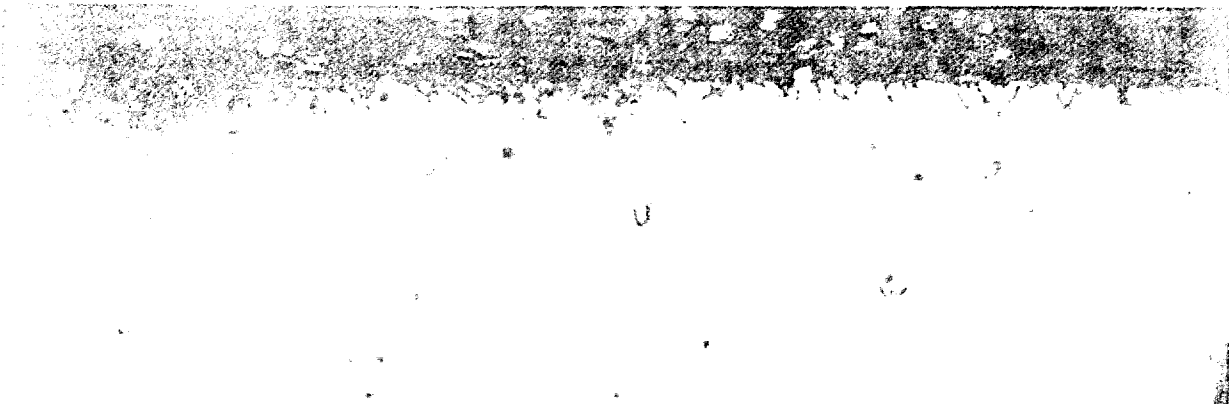
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Fig. 162

Silver Coop on Inconel X
1265°F

Figure 162
Etch: A



Film and Intergranular Oxidation

Fig. 163

Silver Coop on A-286
1800°F

Figure 163
Etch: B

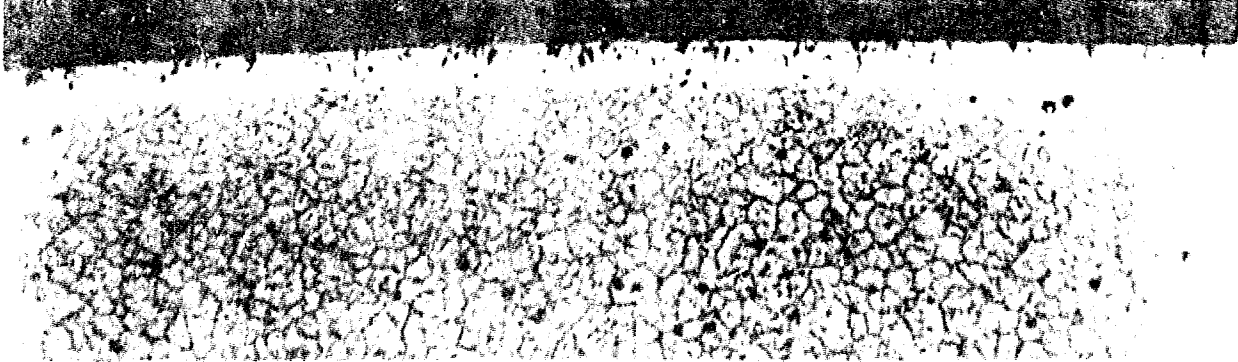


Film and Intergranular Oxidation

Fig. 164

Silver Coop on Reng'41
1800°F

Figure 164
Etch: C



Oxidation and Slight Pitting

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M 4306
Mag: 250X

Silver Coop on L-605
18000g

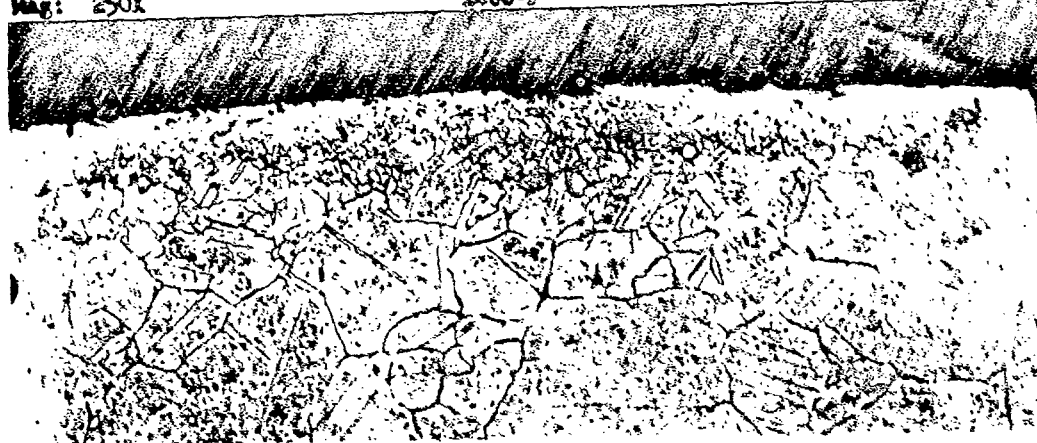
Figure 165
Etch: C



M 4307
Mag: 250X

Silver Coop on Eastellay X
18000g

Figure 166
Etch: C



M 4308
Mag: 250X

Silver Coop on 11C. S.S.
18000g

Figure 167
Etch: D



Intergranular Corrosion

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M 4309 Base Off 990 on Inconel X Figure 168
Mag: 250X 1800°F Etch: A



Extreme Oxidation, Pitting, and Corrosive Alloying

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M 4310

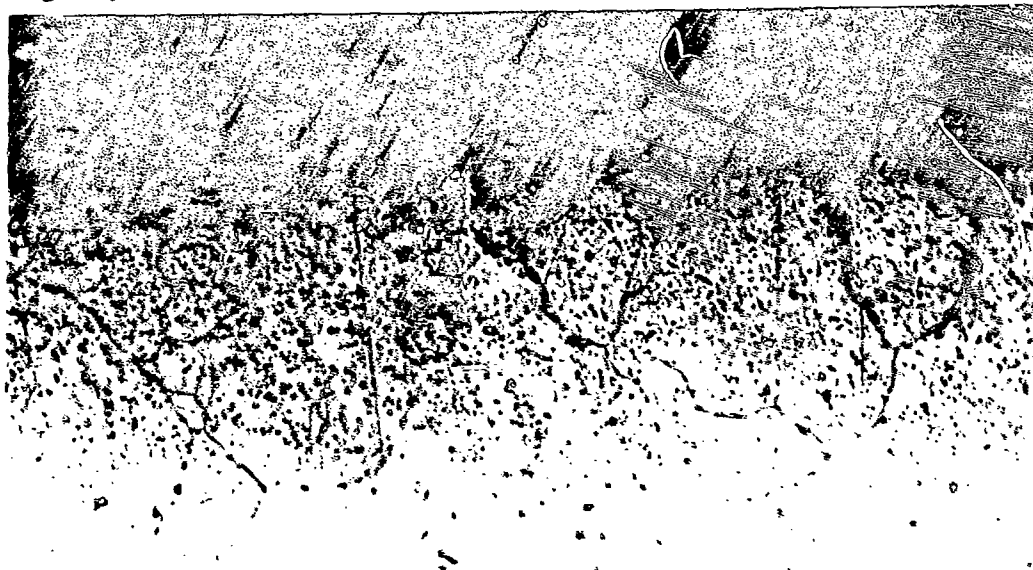
Ease Off 990 on A-286

Figure 169

Mag: 250X

180000

Etch: B



Intergranular Attack and Chemical Corrosion

M 4311

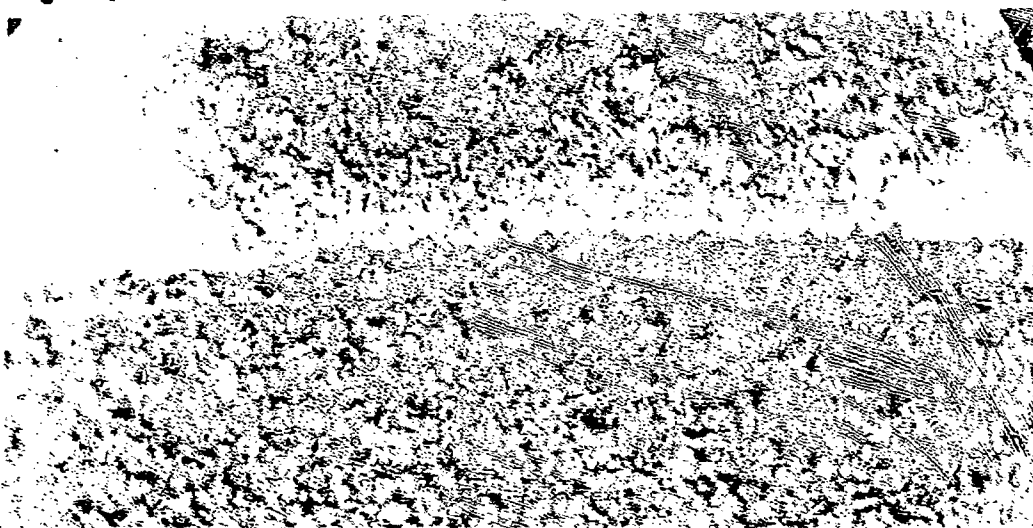
Ease Off 990 on Rene 41

Figure 170

Mag: 250X

180000

Etch: C



Extreme Chemical Corrosion & Corrosive Alloying

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N 4312

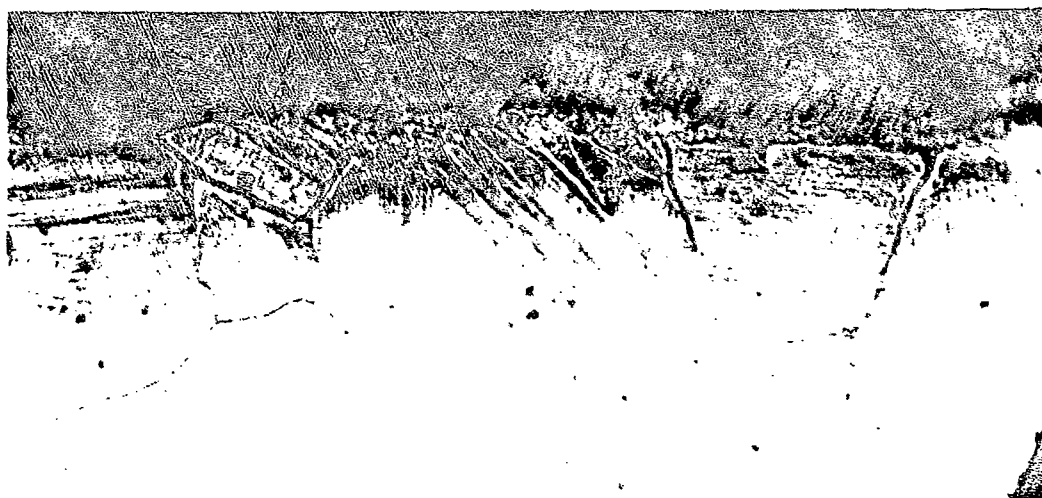
Base Off 990 on L-605

Figure 171

Mag: 250X

1800°F

Etch: C



Intergranular Attack

N 4313

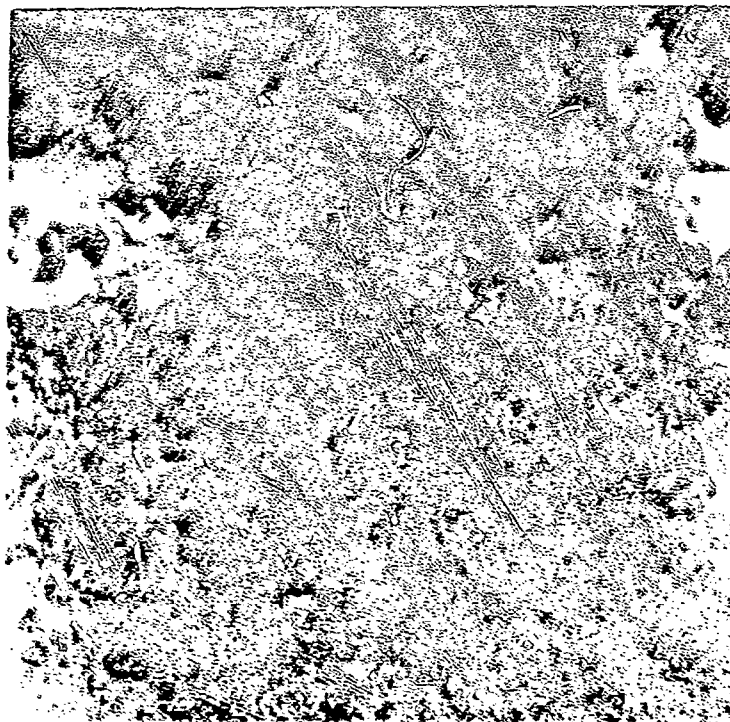
Base Off 990 on Eastellay X

Figure 172

Mag: 250X

1800°F

Etch: C



Extreme Pitting and Corrosion Attack

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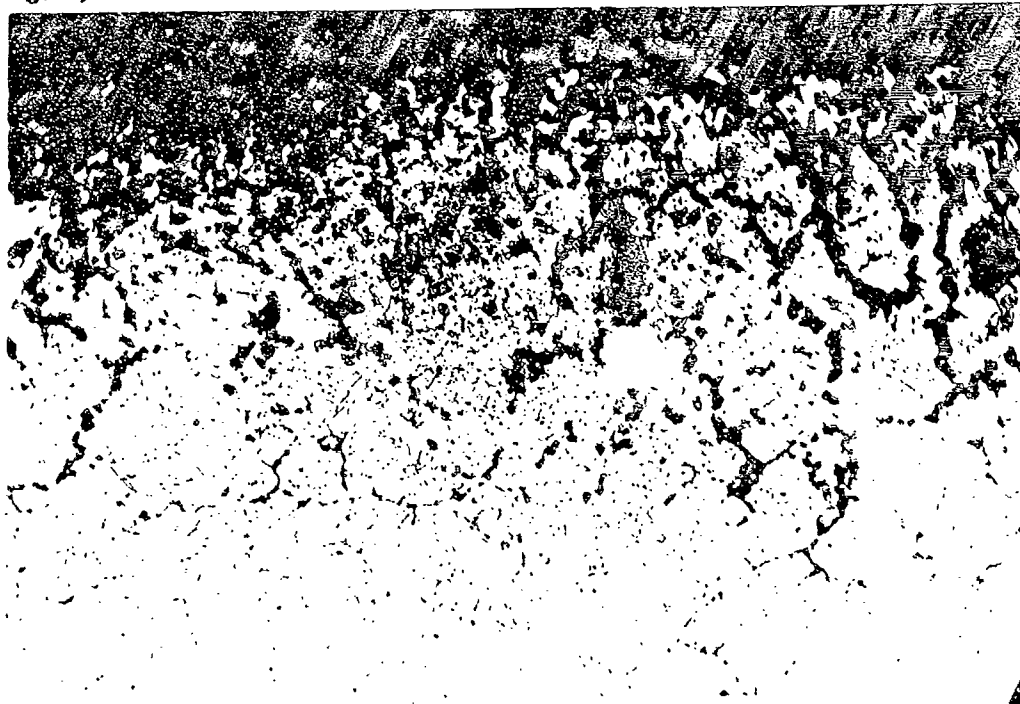
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M 4314
Mag: 250X

Eas. Off 990 on 310 SS
1800°F

Figure 173
Etch: D

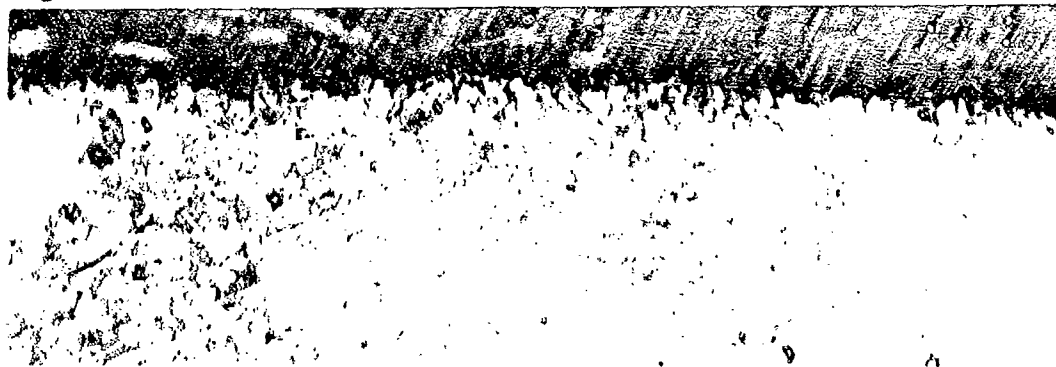


Severe Intergranular Corrosion

M 4315
Mag: 250X

Fel. Pro. 65-A Inconel X
1800°F

Figure 174
Etch: A



Intergranular Oxidation

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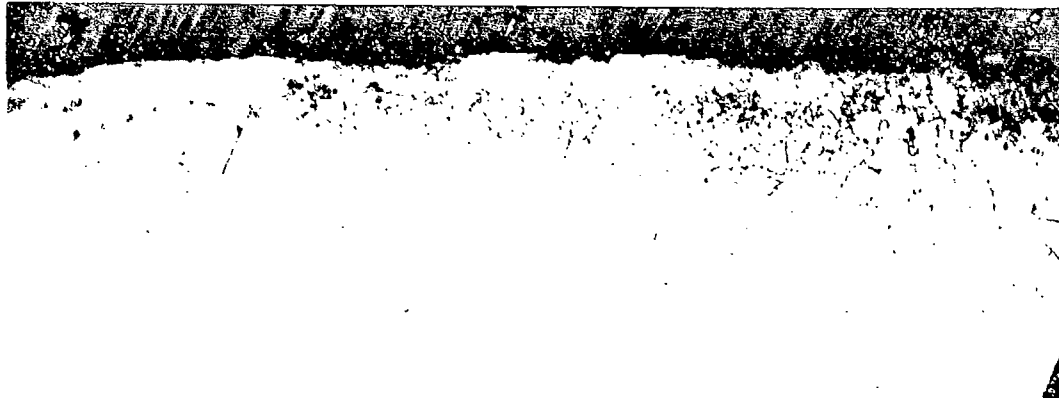
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M 4316
Mag: 250X

Fel. Pro. 65-A on A-286
18000F

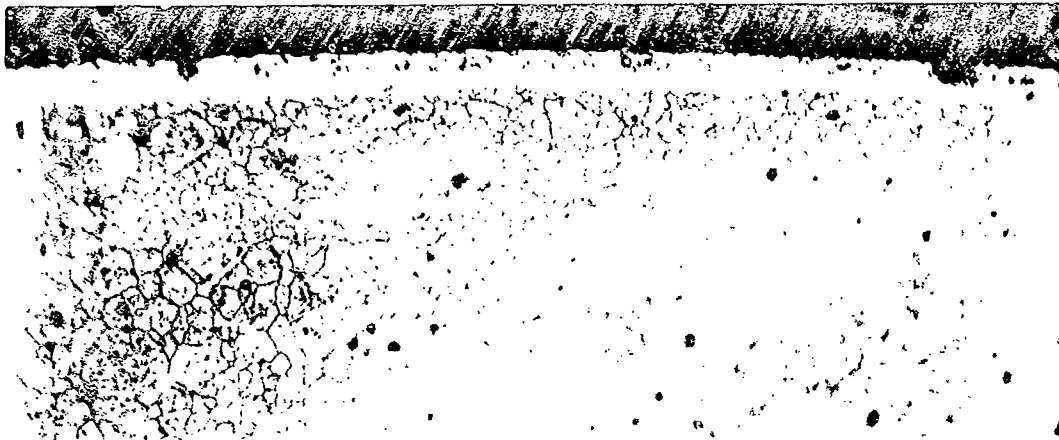
Figure 175
Etch: B



M 4317
Mag: 250X

Fel. Pro. 65-A on René-41
18000F

Figure 176
Etch: C



Oxidation

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M 4318
Mag: 250X

Fel. Pro. 65-A on L-605
1800°F

Figure 177
Etch: C



Oxidation

M 4319
Mag: 250X

Fel. Pro. 65-A on Hastelloy X
1800°F

Figure 178
Etch: C



Oxidation and Slight Pitting

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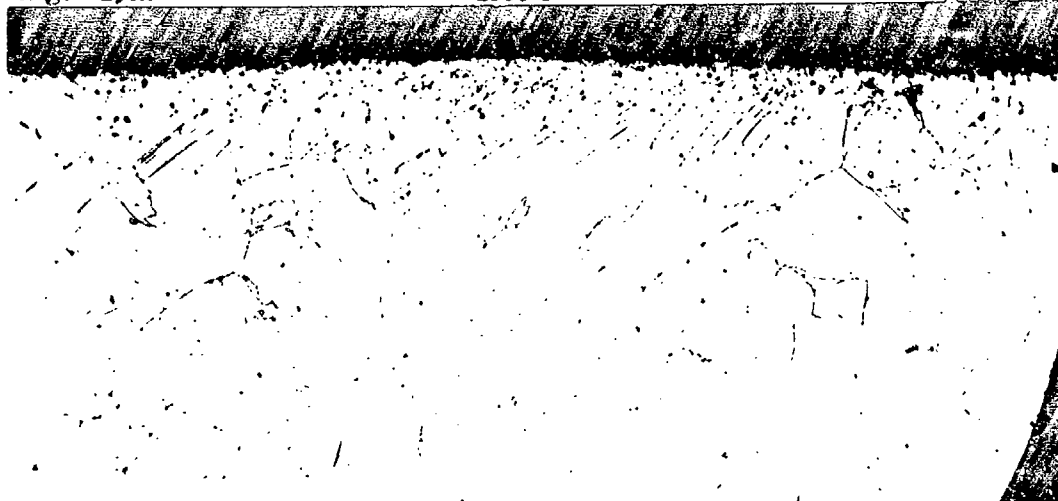
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M 4320

Fel. Pro. 65-A on 310 SS
1800°F

Figure 179
Etch: D

Mag: 250X

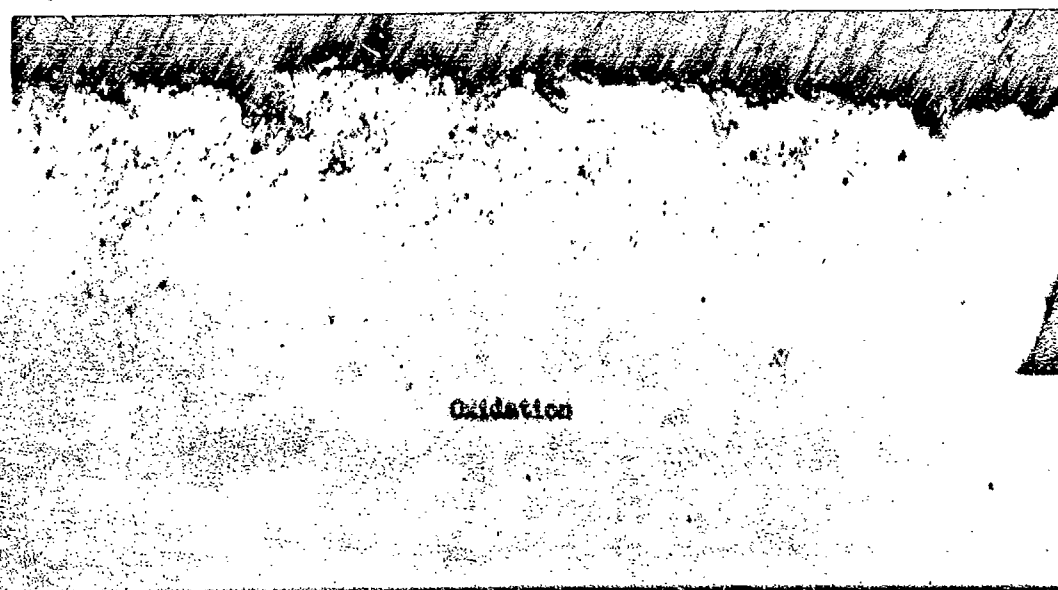


M 4321

DGF 123 on Inconel X
1800°F

Figure 160
Etch: A

Mag: 250X



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M 4322
Mag: 250X

DGF 123 on A-286
1800°F

Figure 181
Etch: S



Scale Oxidation

M 4323
Mag: 250X

DGF 123 on Rene-41
1800°F

Figure 182
Etch: C



Film and Slight Intergranular Oxidation

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M 4324
Mag: 250X

DGF 123 on L-605
18000F

Figure 183
Etch: C

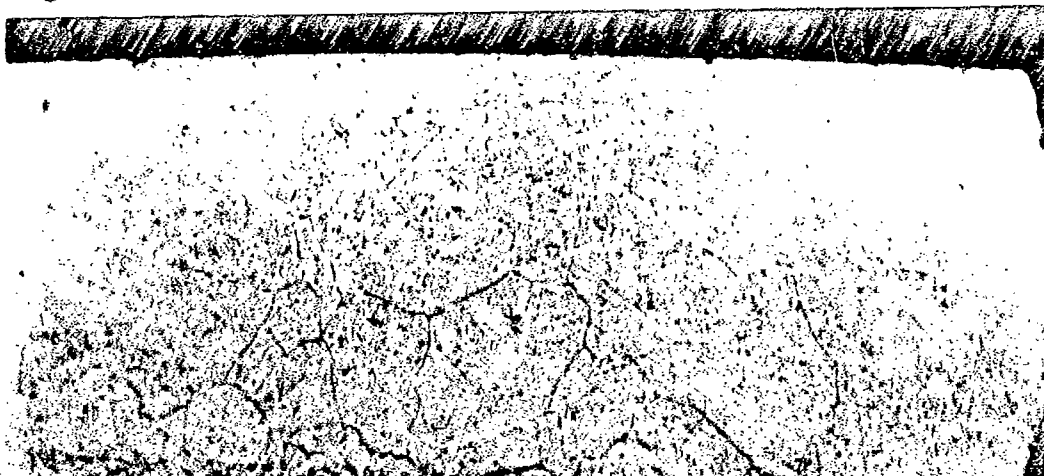


Oxidation

M 4325
Mag: 250X

DGF 123 on Metallurgy X
18000F

Figure 184
Etch: C



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M 4326
Mag: 250X

DDP 123 on 310 SS
1800°F

Figure 185
Etch: D

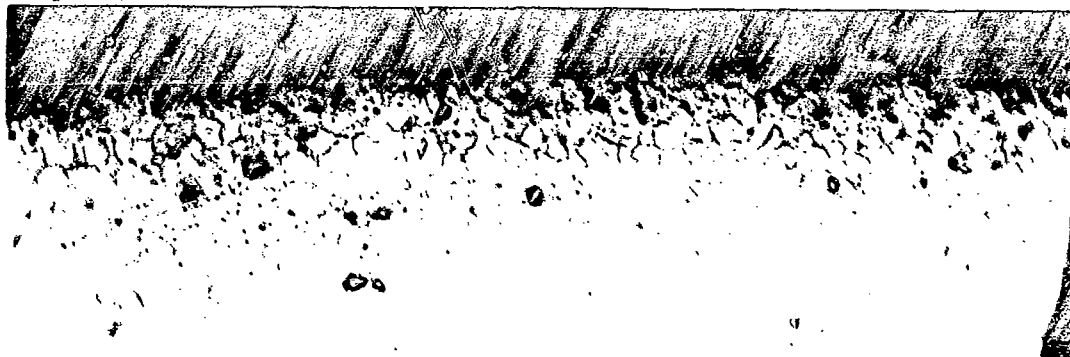


Oxidation

M 4327
Mag: 250X

NIL-T-5544A on Inconel X
1800°F

Figure 186
Etch: A

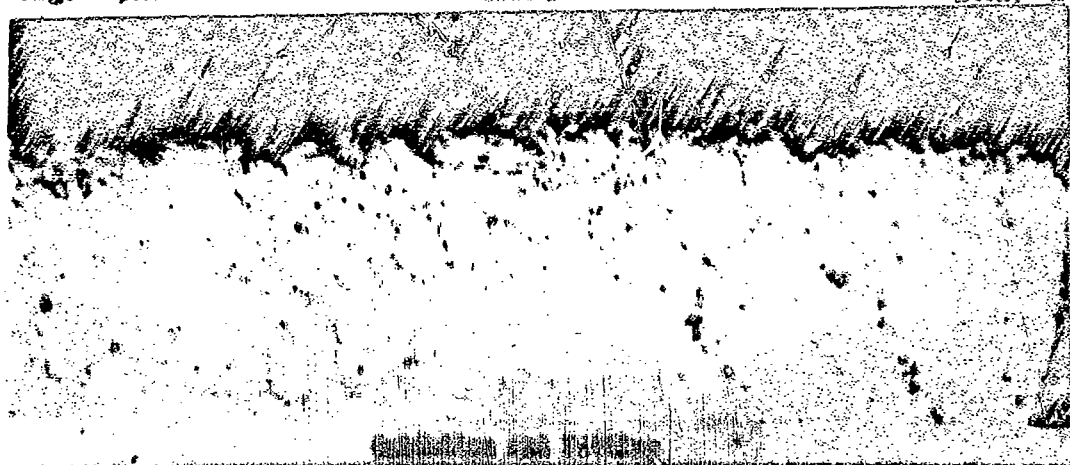


Oxidation

M 4328
Mag: 250X

NIL-T-5544A on A-286
1800°F

Figure 187
Etch: B



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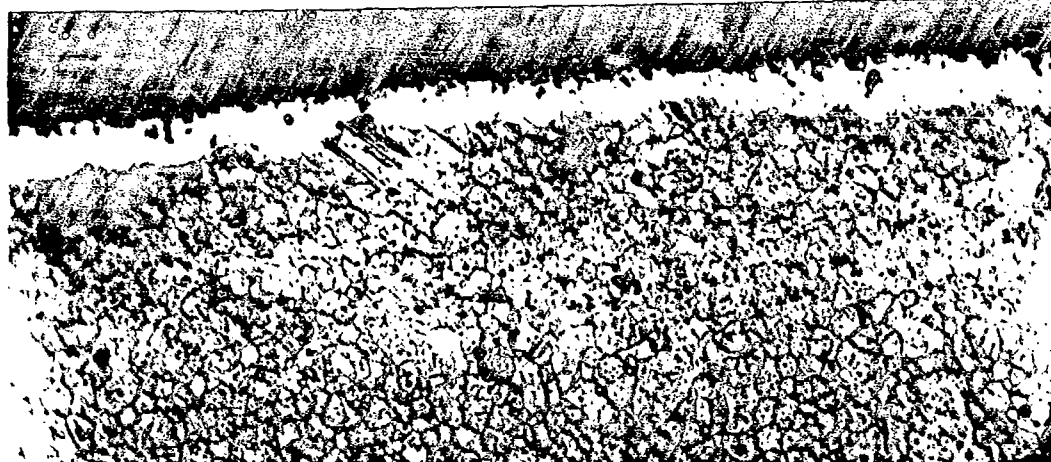
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M 4329
Mag: 250X

MIL-r-5544A on Rem-41
180007

Figure 166
Etch: C

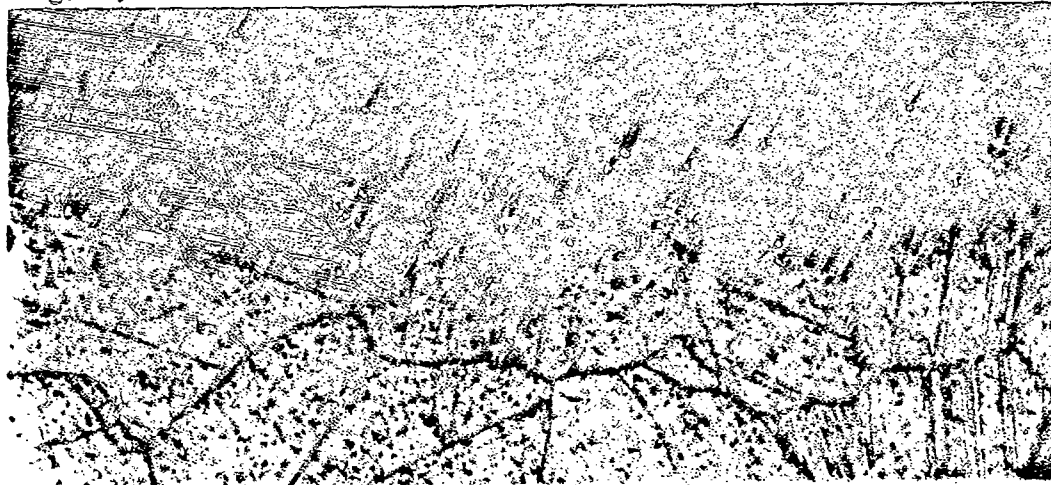


Oxidation and Slight Pitting

M 4330
Mag: 250X

MIL-T-5544A on L-605
180007

Figure 169
Etch: C



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M 4331

MIL-T-5544A on EastElroy X
18000y

Figure 190
Etch: C

Mag: 250X



M 4332

MIL-T-5544A on 310 S.S.
18000y

Figure 191
Etch: D

Mag: 250X



Intergranular Attack

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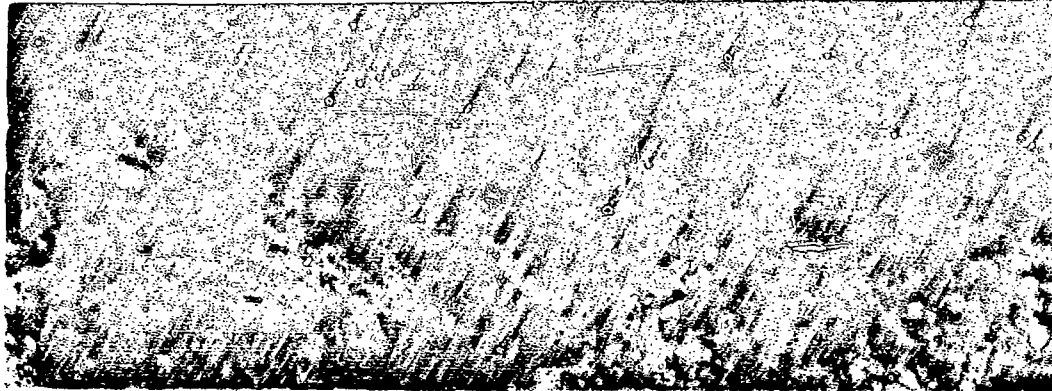
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N 4333
Mag: 250X

Electrofilm 1000 on Inconel X
1800°F

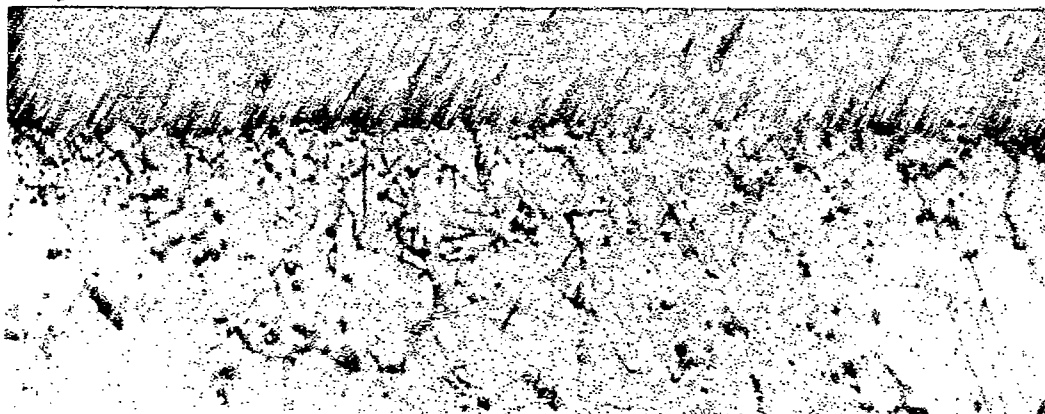
Figure 192
Etch: A



N 4334
Mag: 250X

Orientation
Electrofilm 1000 on A-286
1800°F

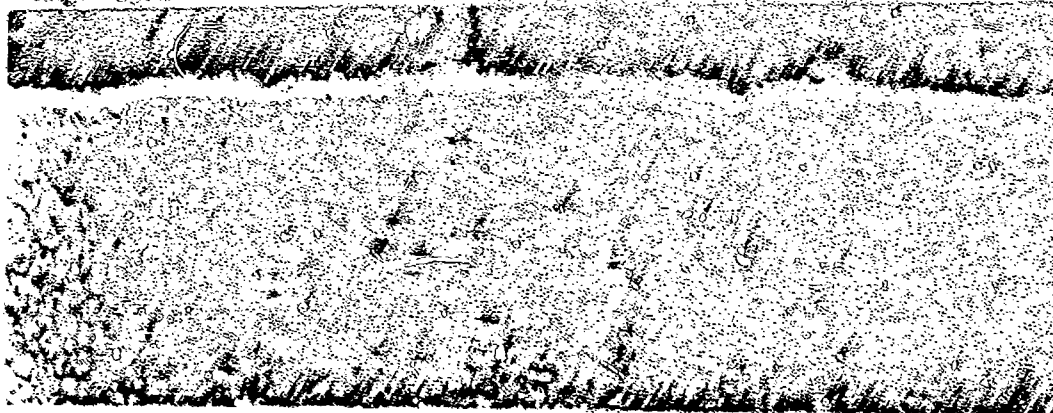
Figure 193
Etch: B



N 4335
Mag: 250X

Electrofilm 1000 on Inconel X
1800°F

Figure 194
Etch: C



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N 4336

Electrofilm 1000 on L-605

Figure 195

Mag: 250X

180097

Etch: C



Oxidation and Slight Pitting

N 4337

Electrofilm 1000 on Eastalloy X

Figure 196

Mag: 250X

180097

Etch: C



Surface Condition After Etching

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M 4338

Electrofilm 1000 on 310 88

Figure 197

Mag: 250X

180007

Sheet J



Slight Intergranular Attack

M 4339

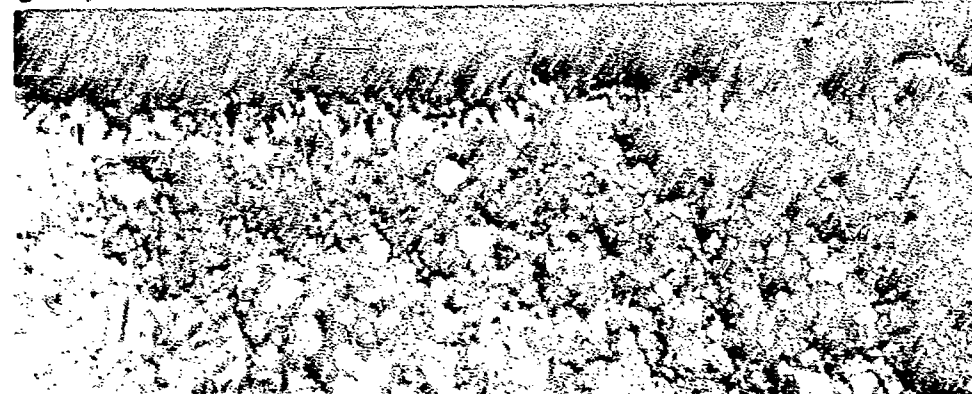
Electrofilm 1005 on Inconel X

Figure 198

Mag: 250X

180007

A



Slight Intergranular Corrosion

M 4340

Electrofilm 1005 on A-486

Figure 199

Mag: 250X

180007

Sheet B



Figure 199

DATE _____

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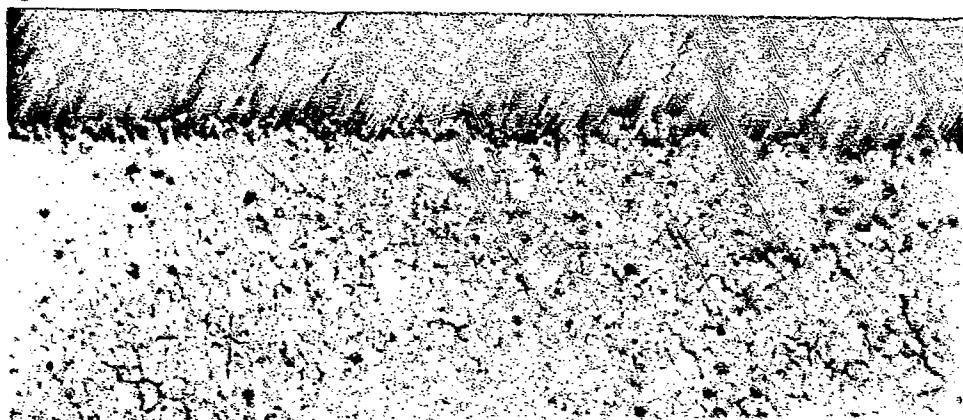
BY: LEON E. ANDERSON

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N 4341
Mag: 250X

Electrofilm 1005 on Bant-41
120097

Figure 200
Etch: C

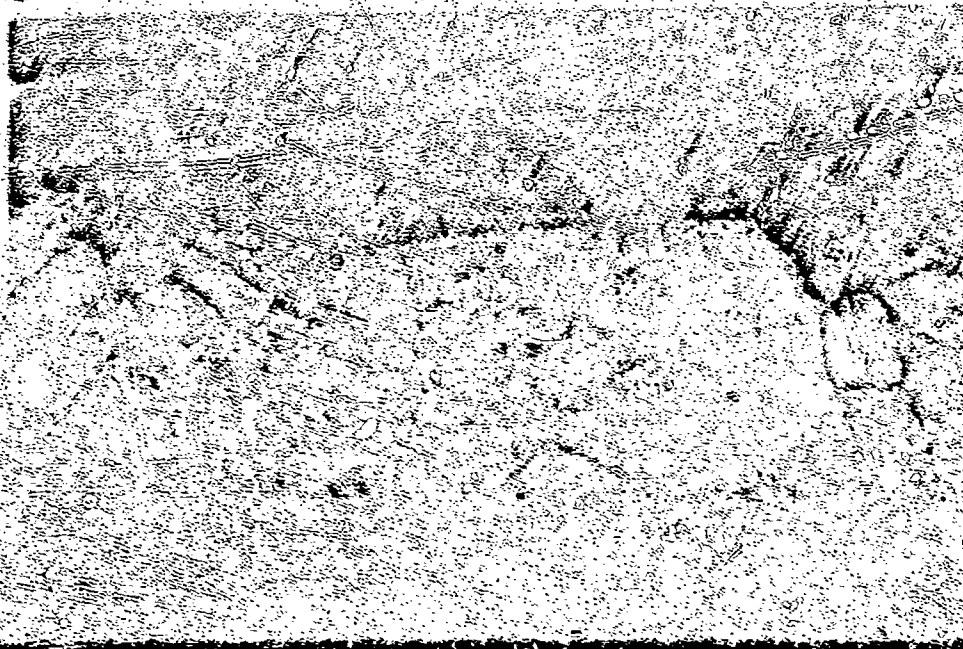


Orientation and Etching

N 4342
Mag: 250X

Electrofilm 1005 on Bant-41
120097

Figure 201
Etch: C



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M 4343

Electrofilm 1005 on Insteelloy X
180000

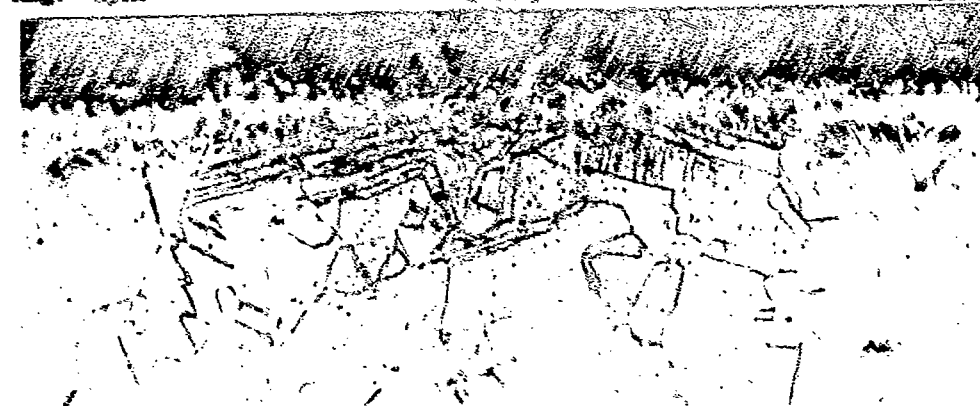
Figure 202
Etch: C



M 4344

Electrofilm 1005 on 310 SS
180000

Figure 203
Etch: D



M 4345

Electrofilm 1005 on Insteelloy X
180000

Figure 204
Etch: A



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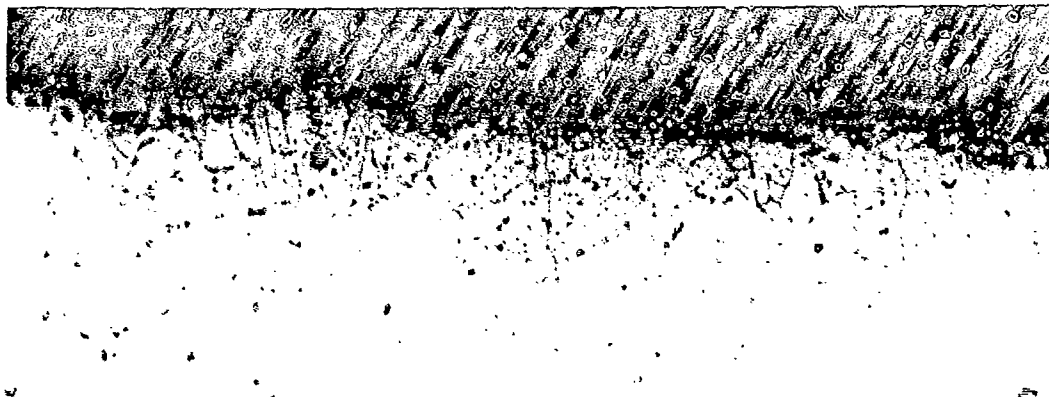
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M 4346
Mag: 250X

Electrofilm 200T on A-286
1800°F

Figure 205
Etch: B

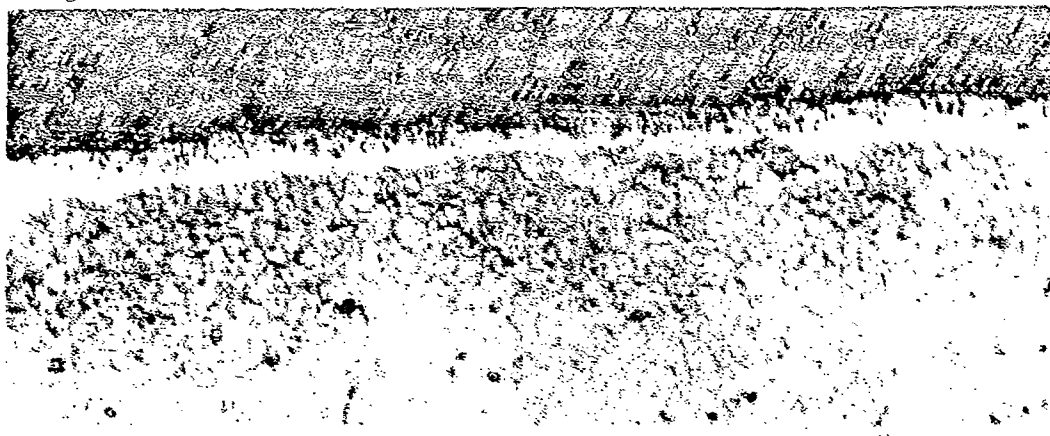


Intergranular Oxidation and Pitting

M 4347
Mag: 250X

Electrofilm 200T on Rand-41
1800°F

Figure 206
Etch: C



Oxidation

M 4340
Mag: 250X

Electrofilm 2007 on L-605
180007

Figure 207
Etch: C



Oxidation and Pitting

M 4349
Mag: 250X

Electrofilm 2007 on Hastelloy X
180007

Figure 208
Etch: C



Slight Oxidation

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Sample
Mag: 1800X

Electrofilm 66C on A-286
18000P

Figure 211
Etch: B

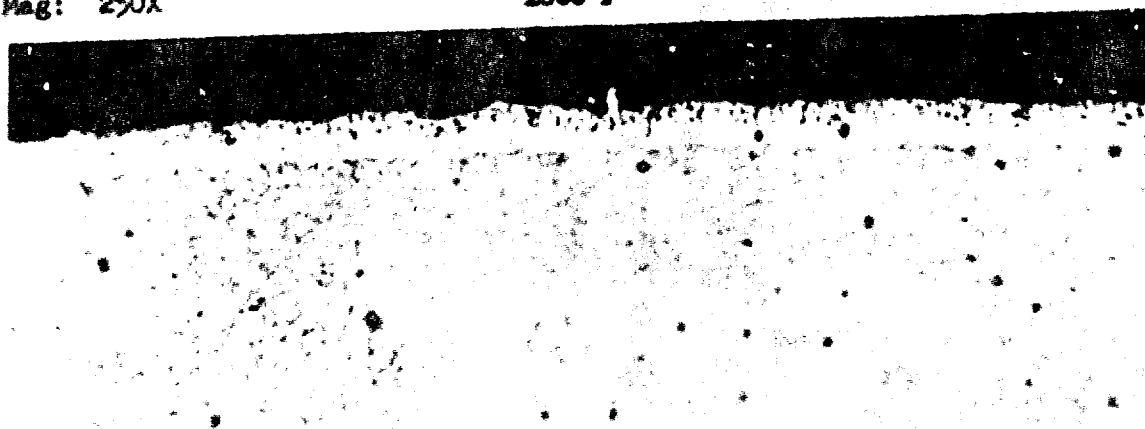


Pitting

N 4353
Mag: 250X

Electrofilm 66C on Rene-41
18000P

Figure 212
Etch: C



Oxidation

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M 4354
Mag: 250X

Electrofilm 66C on L-509
1800°F

Figure 213
Etch: C



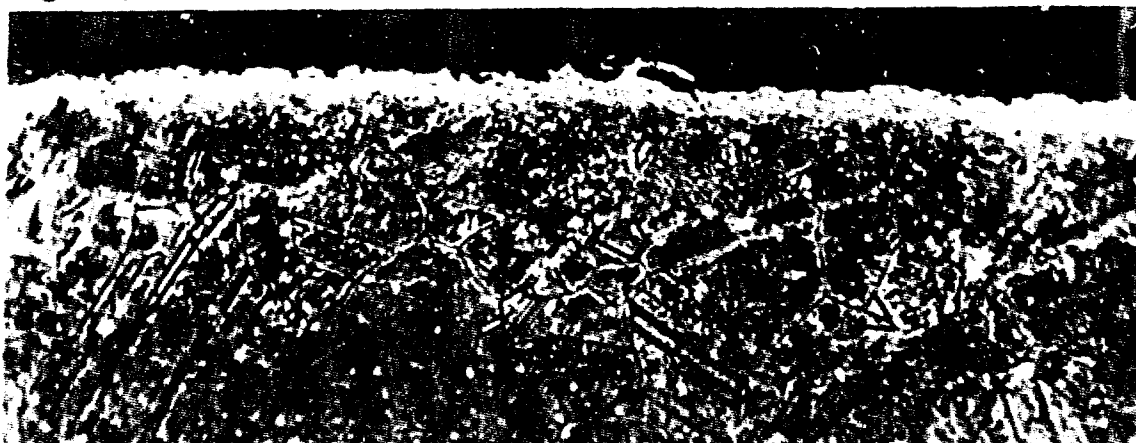
Oxidation and Slight Pitting

M 4355
Mag: 250X

Electrofilm 66C on
1800°F

X

Figure 214
Etch: C



Pitting

042-23335

M 4355
Mag: 250X

Electrofilm 66C on 310 SS
18000F

Figure 215
Etch: D



Oxidation and Slight Pitting

M 4357
Mag: 250X

Phosphathern RN on Inconel X
1800°F

Figure 216
Etch: A



Extreme Chemical Corrosion and Pitting

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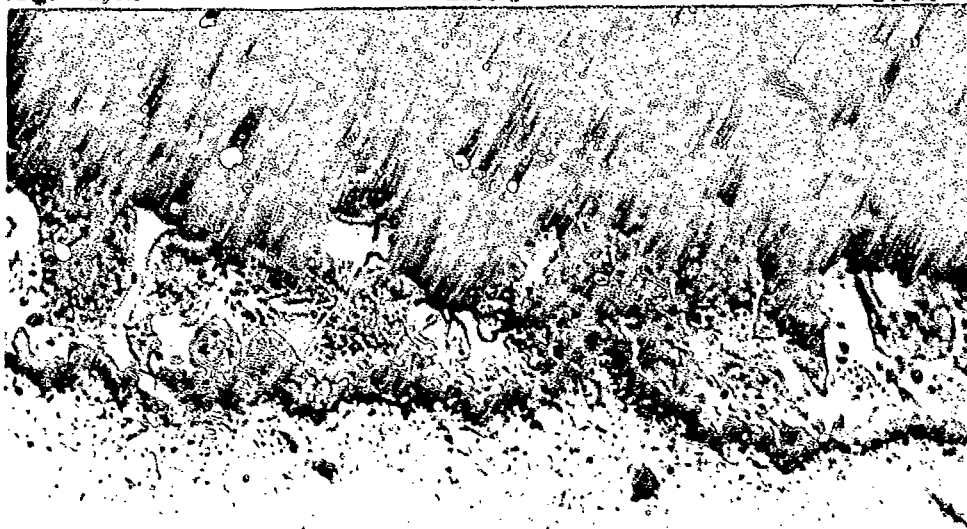
M 4358

Mag: 250X

Phosphatase RM on A-286
1800%

Figure 217

Etch: B



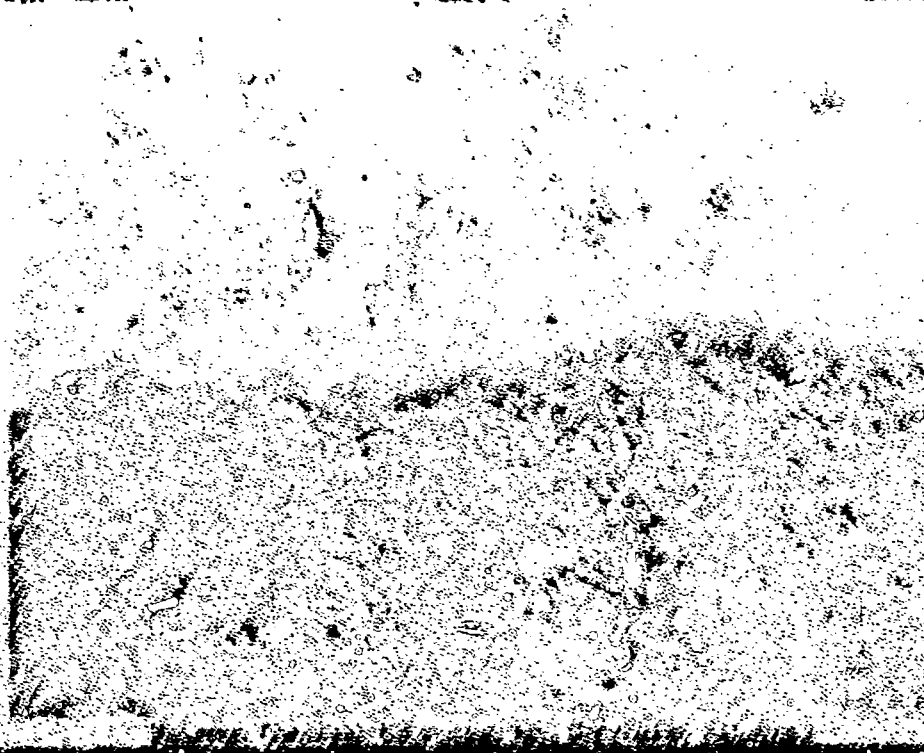
M 4359

Mag: 250X

Extreme Pitting and Corrosive Alloying
Phosphatase RM on Rene-41
1800%

Figure 218

Etch: C



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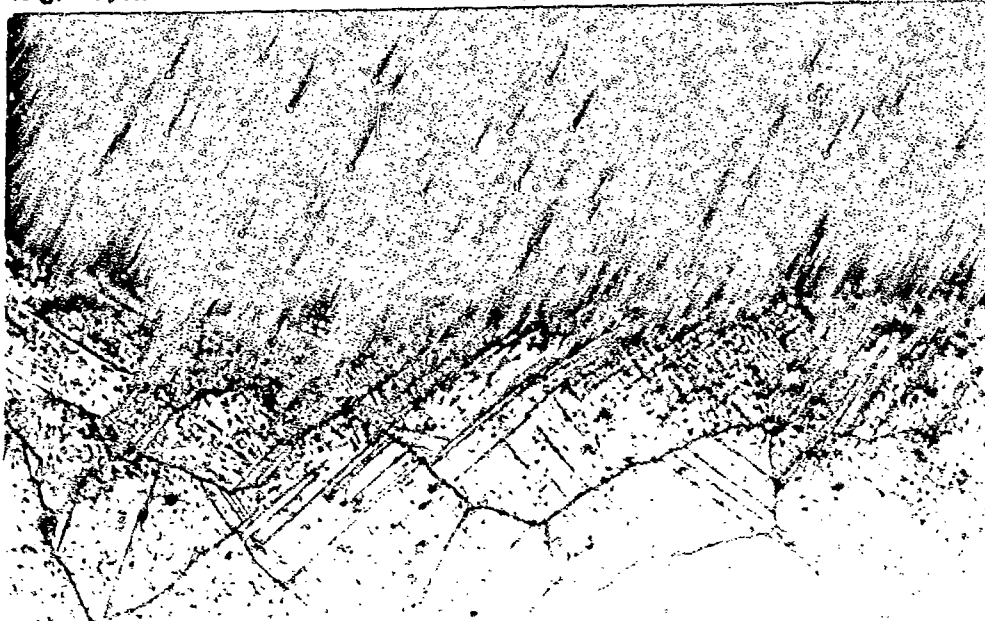
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M 4360

Phosphaterra RM on L-605
1800°

Figure 219
Etch: 6



Severe Chemical Corrosion

DATE _____

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M 4361 Phosphatherm RM on Hastelloy X Figure 220
Mag: 250X 180007 Etch: C



Extreme Chemical Corrosion and Corrosive Alloying

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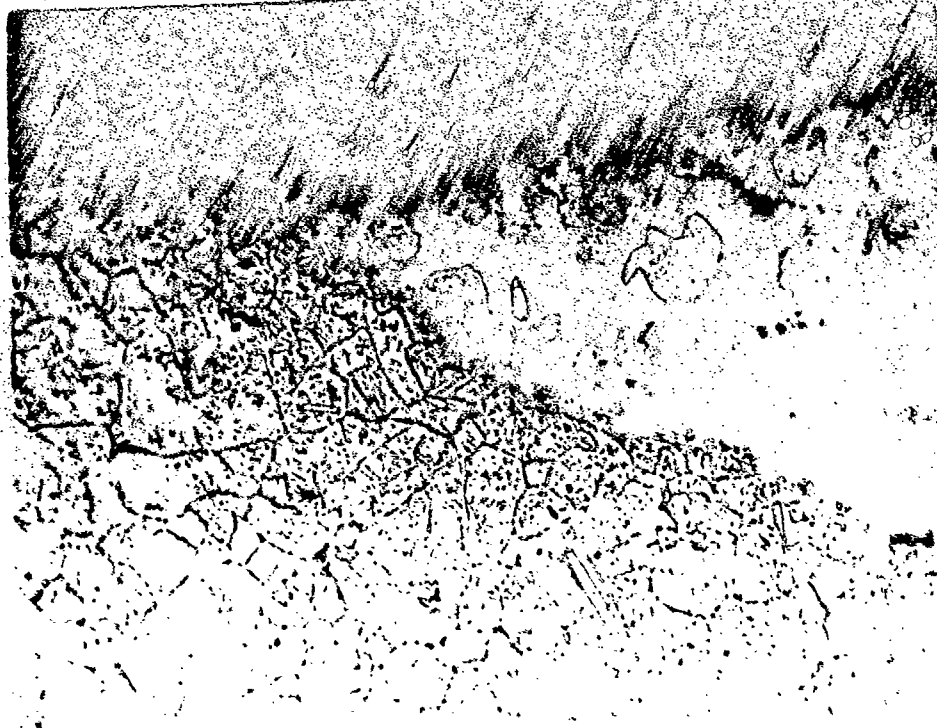
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M 4362
Mag: 250X

Phosphatherm BN on 310 SS
18000p

Figure 221

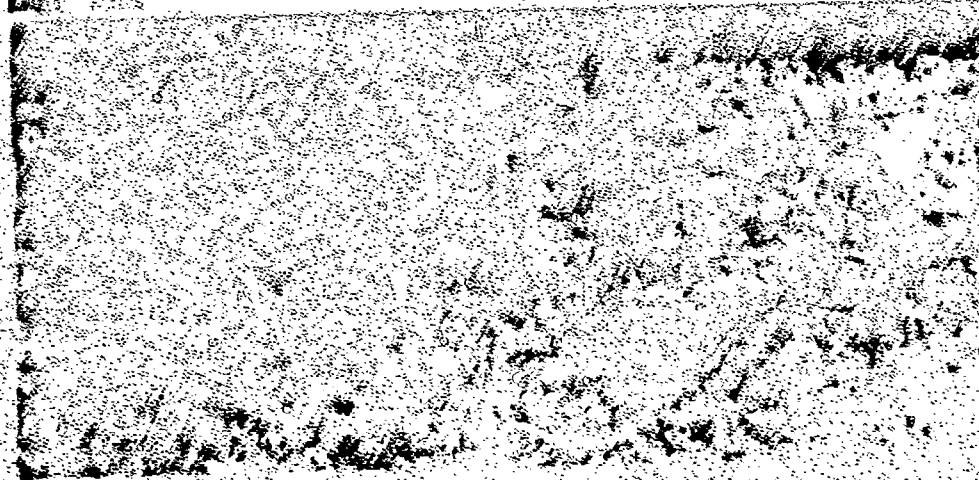


Extreme Pitting and Corrosive Alloying

M 4353
Mag: 250X

Sodium Silicate on Inconel X
18000p

Figure 222
Etch: A



Slight Pitting

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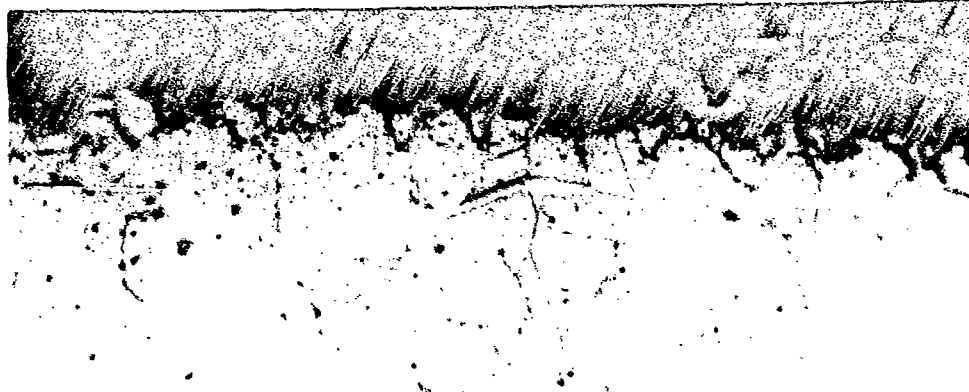
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M 4364
Mag: 250X

Sodium Silicate on A-285
180097

Figure 223
Etch: B

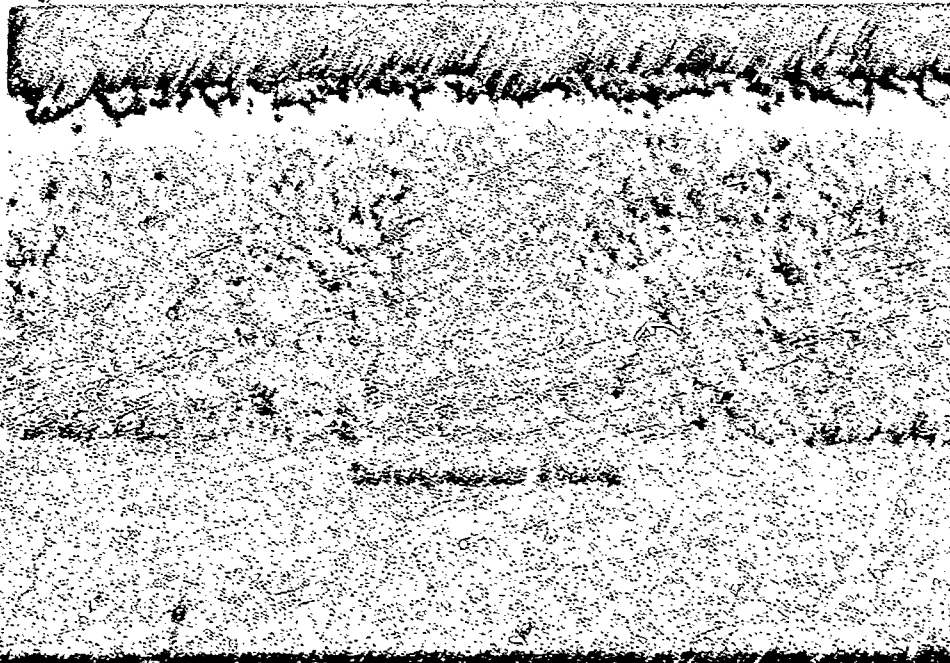


Pitting and Intergranular Attack

M 4365
Mag: 250X

Sodium Silicate on Rand-41
180097

Figure 224
Etch: C



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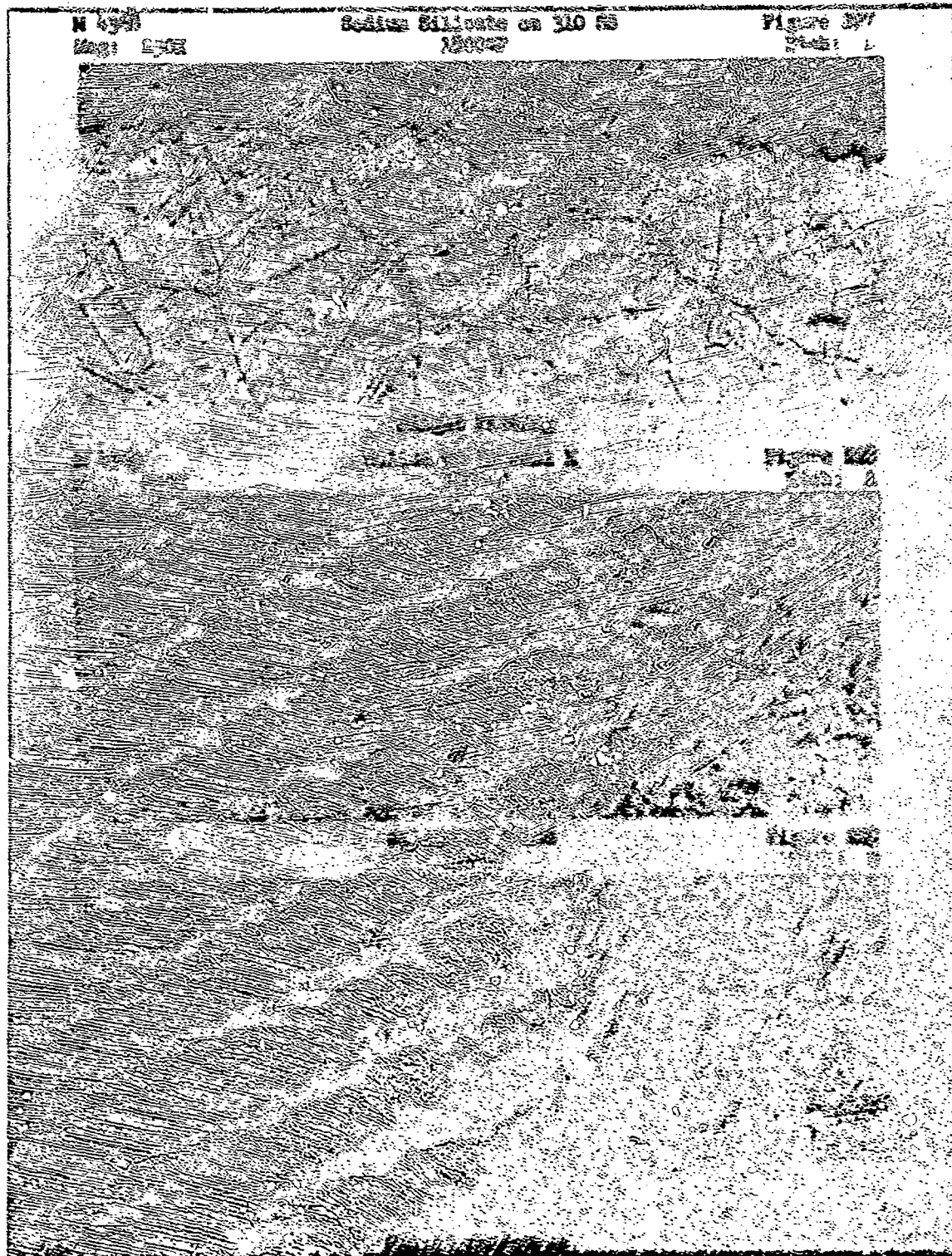
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N 494
Mag: 1/2

Scale: 1:1000
10000'

Figure 397
Sheet: 1

Figure 398
Sheet: 2

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REVISED D4E-238395

H 4371
Mag: 250X

Silica on René-41
18000x

Figure 230
Etch: C



H 4372
Mag: 250X

Silica on L-605
18000x

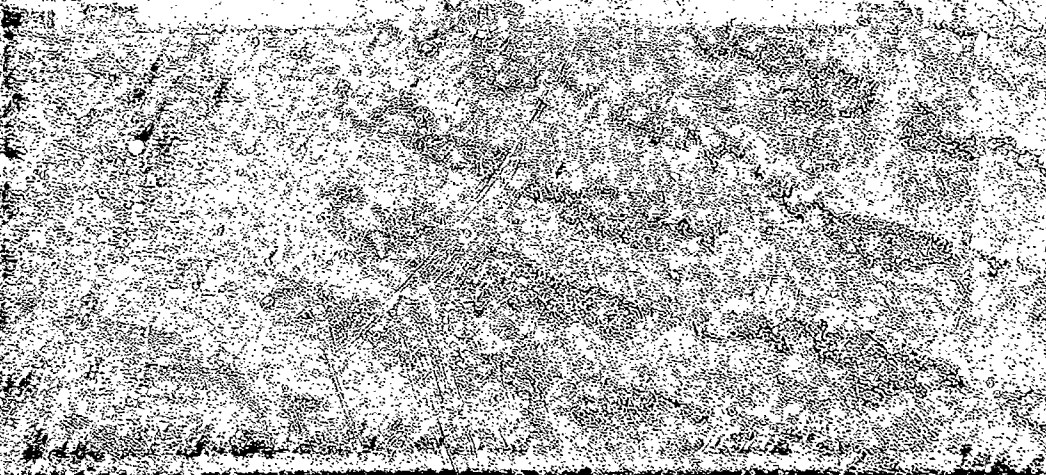
Figure 231
Etch: C



H 4373

Silica on " " 18000x

Figure 232



Silica on 310 SS
1800°F

Figure 233
Etch: D

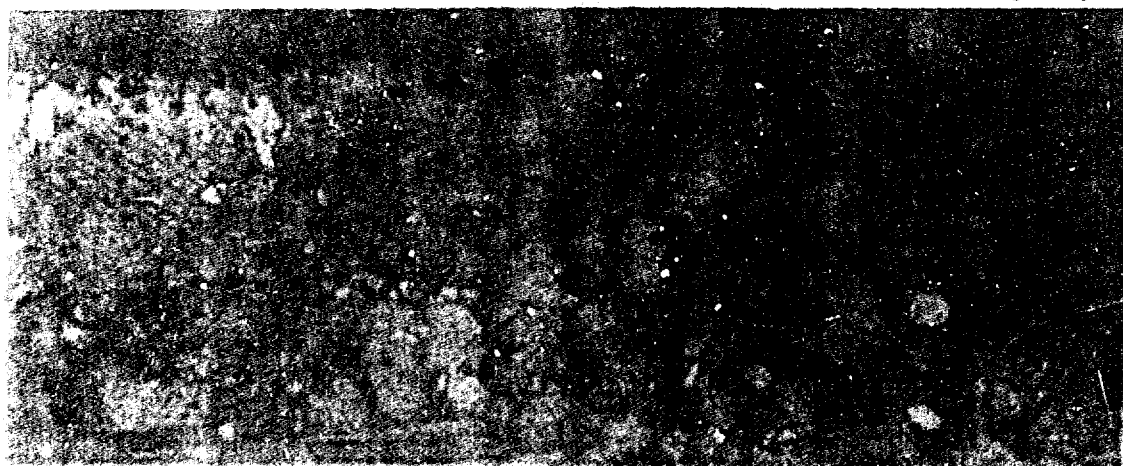


Slight Intergranular Attack

Fig: 250X

Milk of Magnesia on Inconel X
1800°F

Figure 234
Etch: A



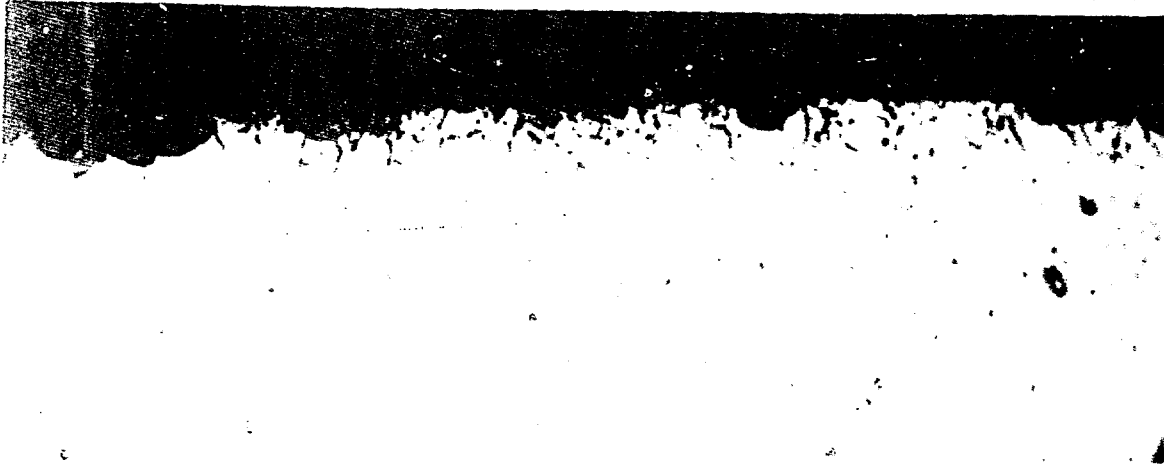
Film and Intergranular Oxidation

046-239397

M 4370
Mag: 250X

Milk of Magnesia on A-286
1800°F

Figure 235
Etch: B



Pitting and Intergranular Oxidation

M 4377
Mag: 250X

Milk of Magnesia on René-41
1800°F

Figure 236
Etch: C



Oxidation

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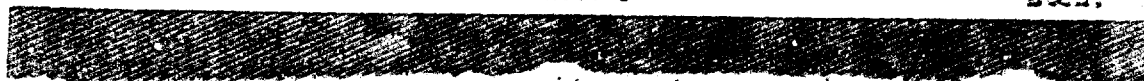
AT LAMARCA MISSOURI

100-20000

M 4378
Mag: 250X

Milk of Magnesia on L-605
18000°

Figure 237
Etch: C



M 4379
Mag: 250X

Milk of Magnesia on Hastelloy X
18000°

Figure 238
Etch: C



M 4380
Mag: 250X

Milk of Magnesia on 310 SS
18000°

Figure 239
Etch: D



Orientation

Boat (Navy) 10000

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M 4381
Mag: 250X

Magnesium Oxide on Inconel X
12500X

Figure 240
Etch: A



Oxidation and Pitting

M 4382
Mag: 500X

Magnesium Oxide on A-286
12500X

Figure 241
Etch: B

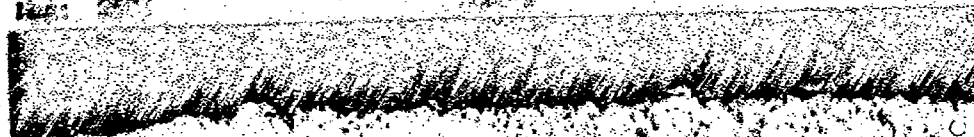


Figure 2-42
Mag: 250X

Magnesium Oxide on Rene-41
1800°F

Figure 2-42
Etch: C

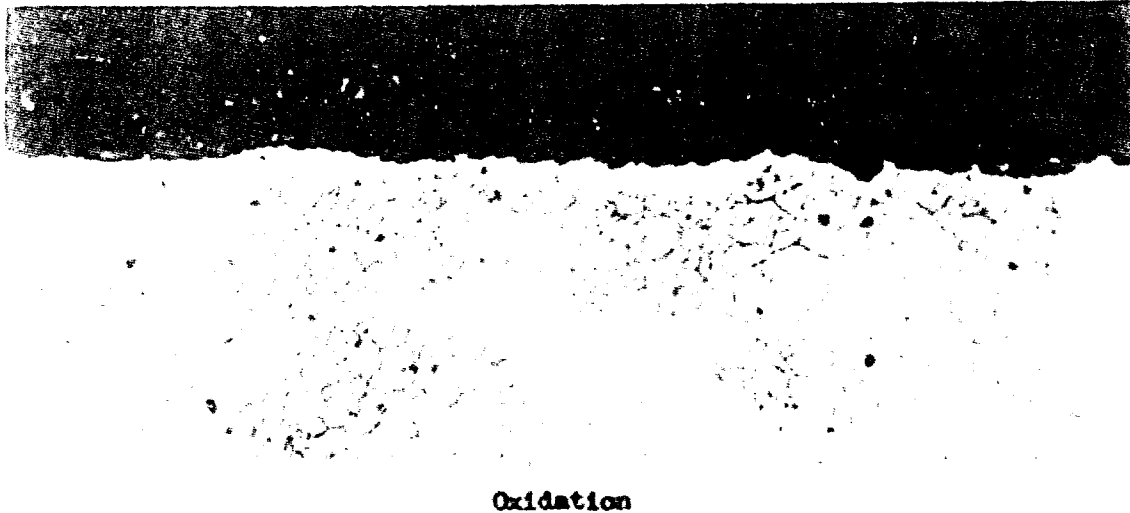
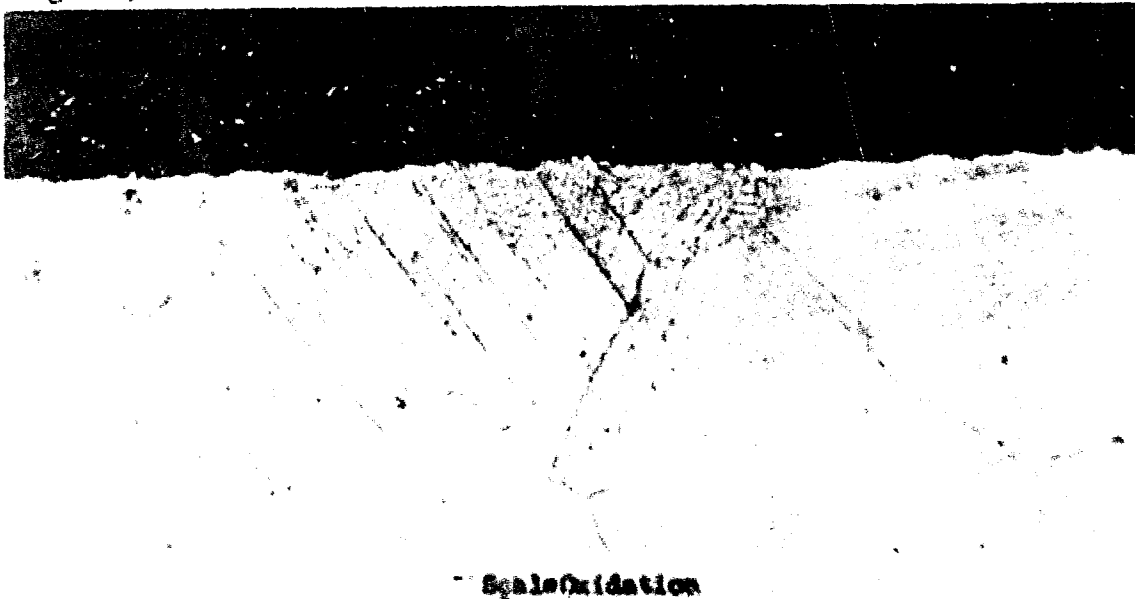


Figure 2-43
Mag: 250X

Magnesium Oxide on L-605
1800°F

Figure 2-43
Etch: C



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M 4385
Mag: 250X

Magnesium Oxide on Metalloy X
1800°F

Figure 244
Etch: C

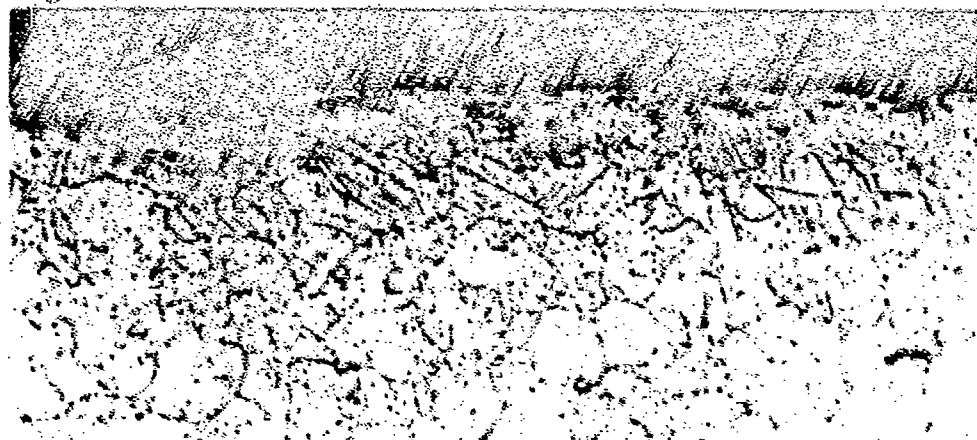


Single Oxidation

M 4386
Mag: 250X

Magnesium Oxide on 310 SS
1800°F

Figure 245
Etch: D



Corrosion

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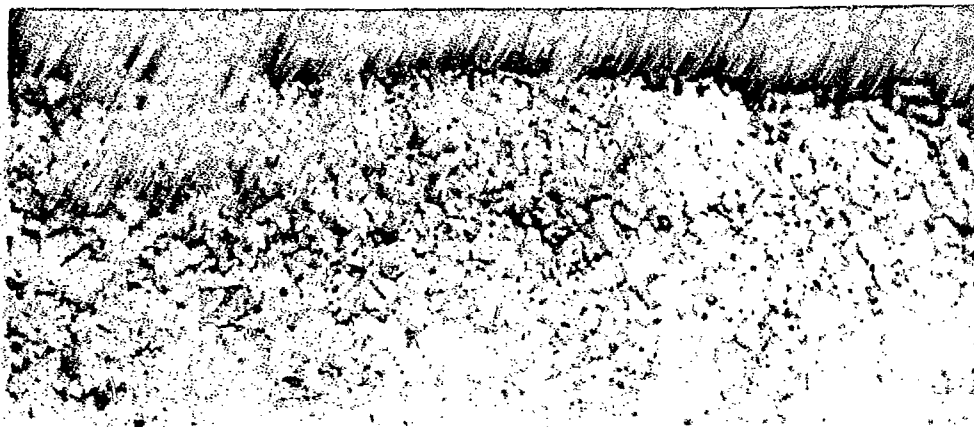
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N 4367
Mag: 250X

Boron Nitride on Inconel X
1800°F

Figure 246
Etch: A

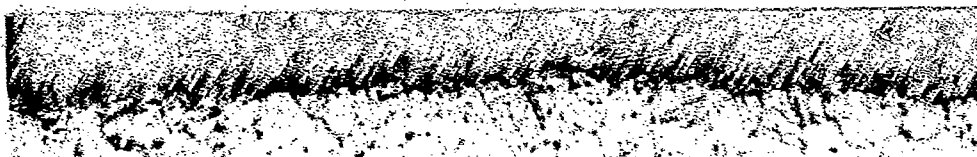


Oxidation

N 4368
Mag: 250X

Boron Nitride on A-286
1800°F

Figure 247
Etch: B



Oxidation

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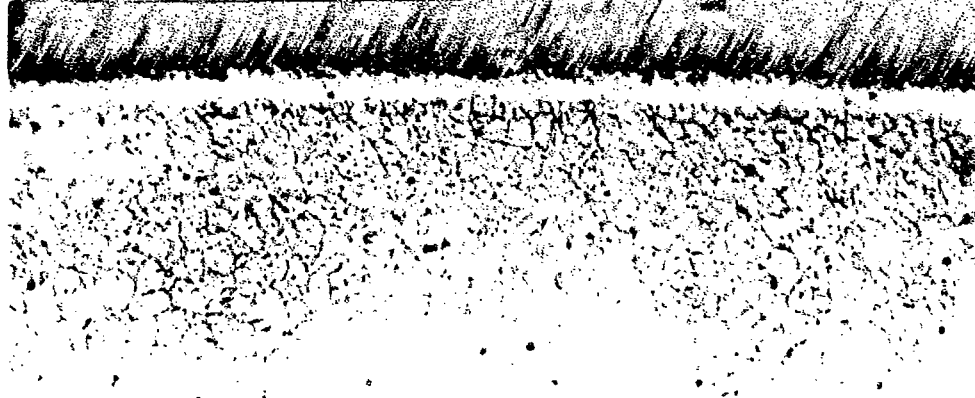
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M 4389

Boron Nitride on Bend-41

Figure 248

Mag: 250X



Oxidation

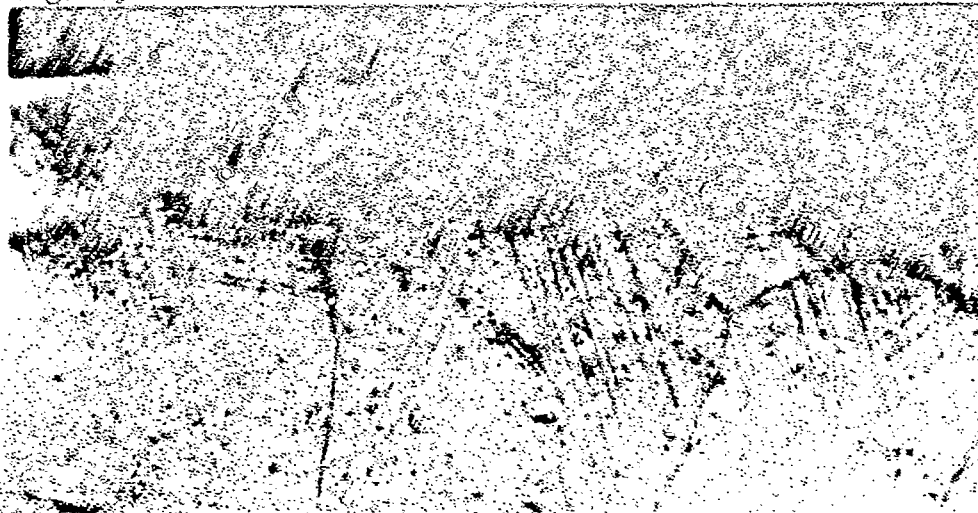
M 4390

Boron Nitride on L-605

Figure 249

Mag: 250X

Etch: C



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REVISED D4B-238604

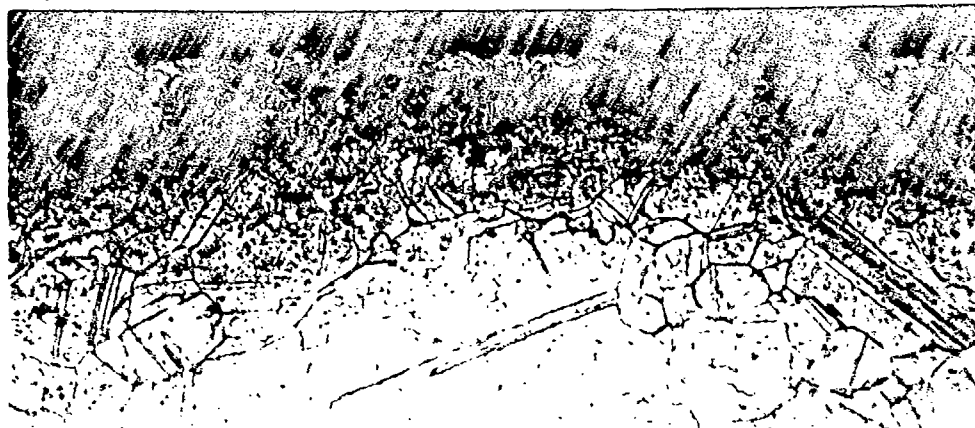
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M 4391
Mag: 250X

Boron Nitride on Eastelloy X
1800°F

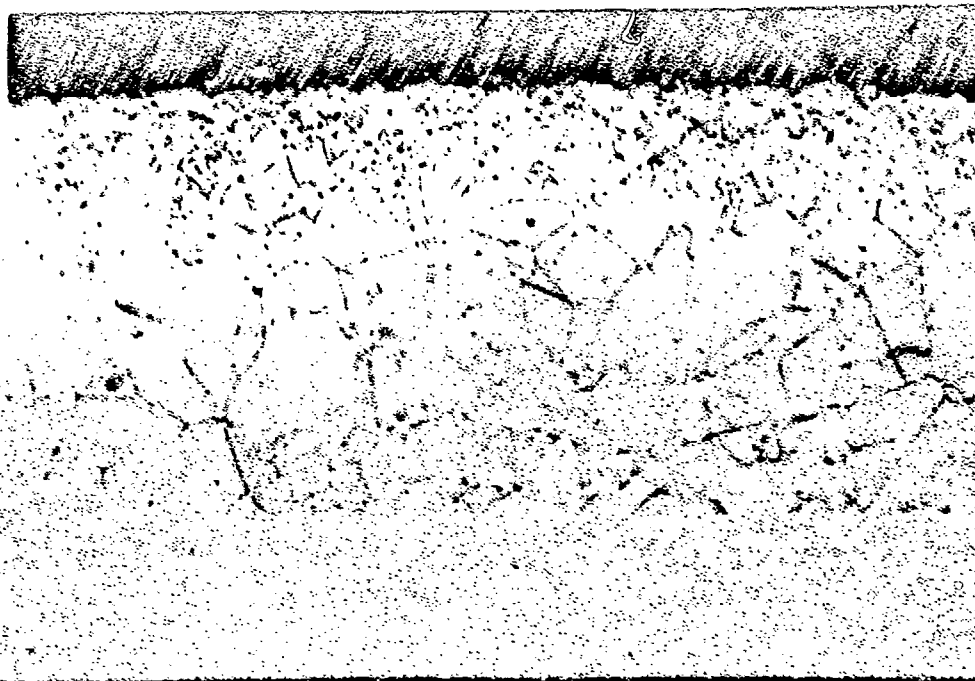
Figure 250
Etch: C



M 4392
Mag: 250X

Boron Nitride on 310 SS
1800°F

Figure 251
Etch: D



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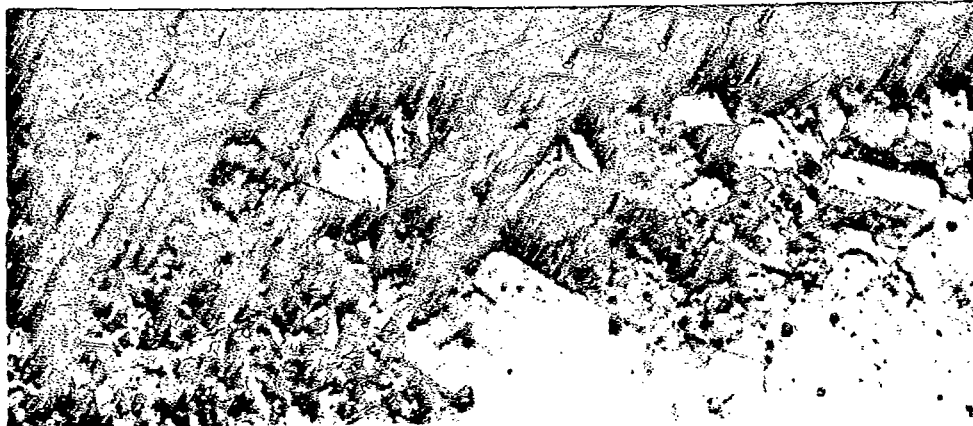
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M 4393
Mag: 250X

Boric Oxide on Inconel X
1800°F

Figure 252
Etch: A



Intergranular Oxidation

M 4394
Mag: 250X

Boric Oxide on A-286
1800°F

Figure 253
Etch: B



Oxidation

DATE

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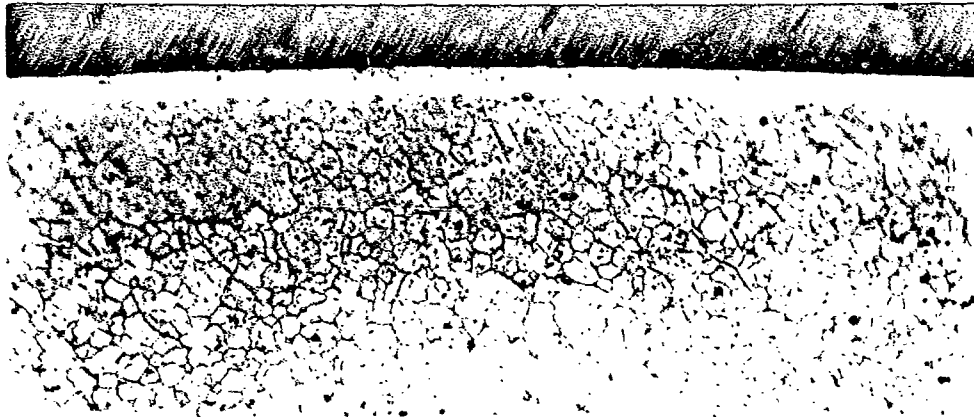
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M 4395
Mag: 250X

Boric Oxide on Rene-41
180007

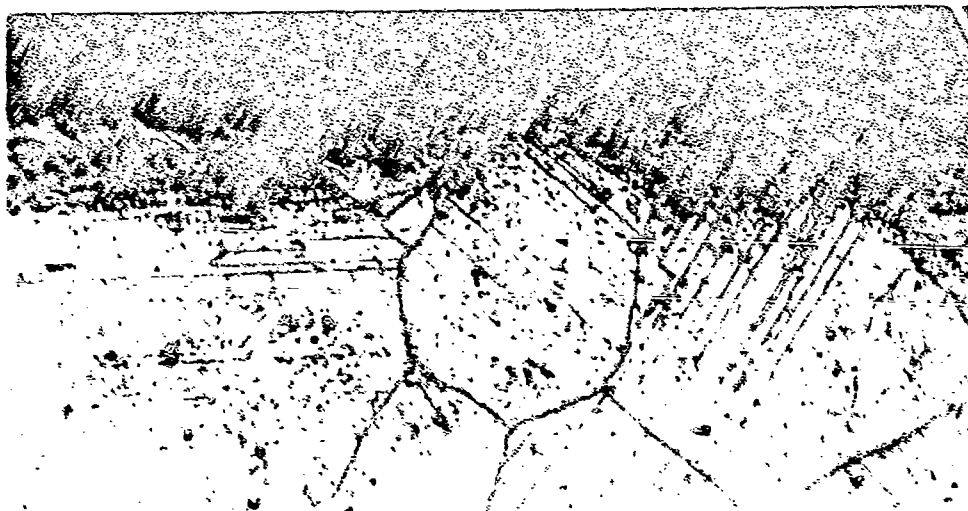
Figure 254
Etch: C



M 4396
Mag: 250X

Boric Oxide on L-605
180007

Figure 255
Etch: C



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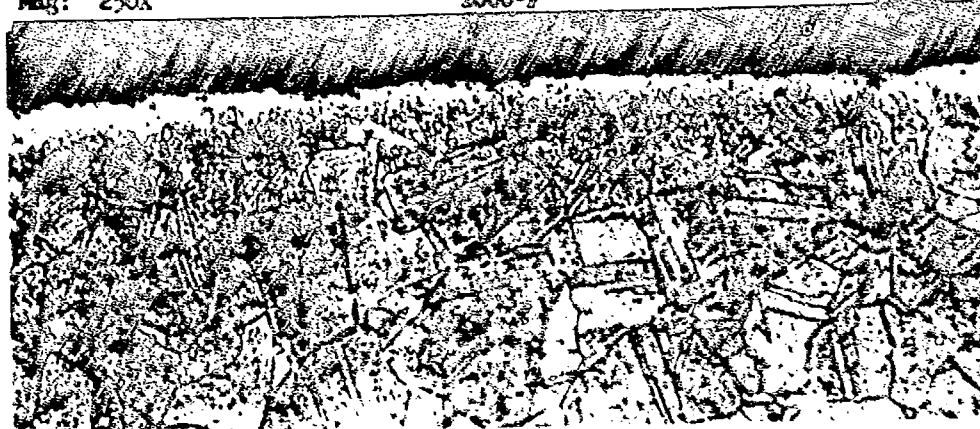
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M 4397
Mag: 250X

Boric Oxide on Hastelloy X
1800°F

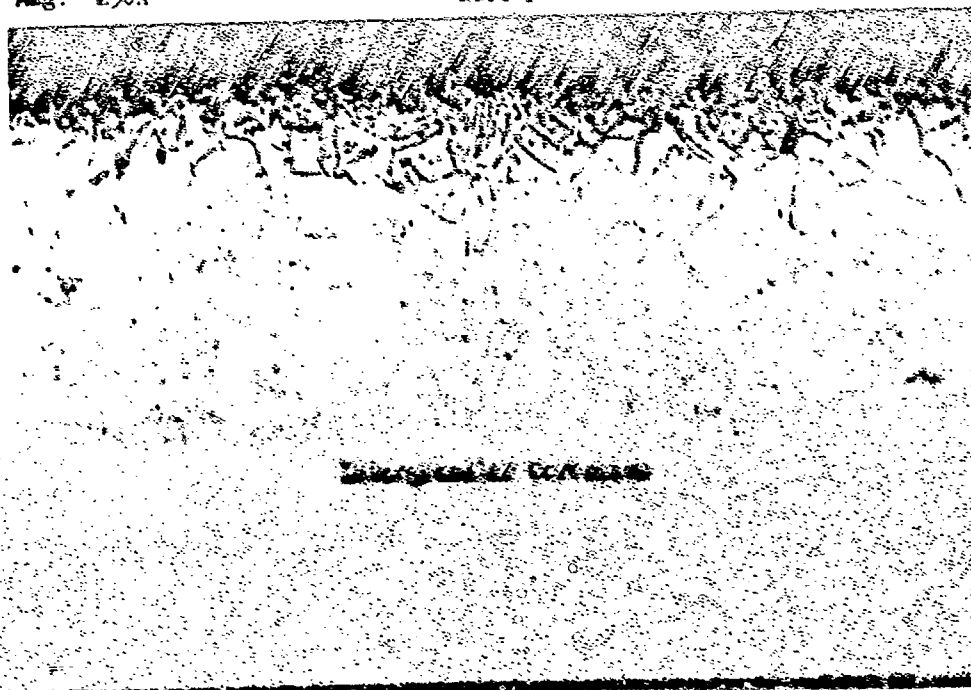
Figure 256
Etch: C



M 4398
Mag: 250X

Boric Oxide on 310 SS
1800°F

Figure 257
Etch: D



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REVISED D4E-238608

M 4399 Molykote X-100 on Inconel X Figure 258
Mag: 250X 800°F Etch: A



Intergranular Attack

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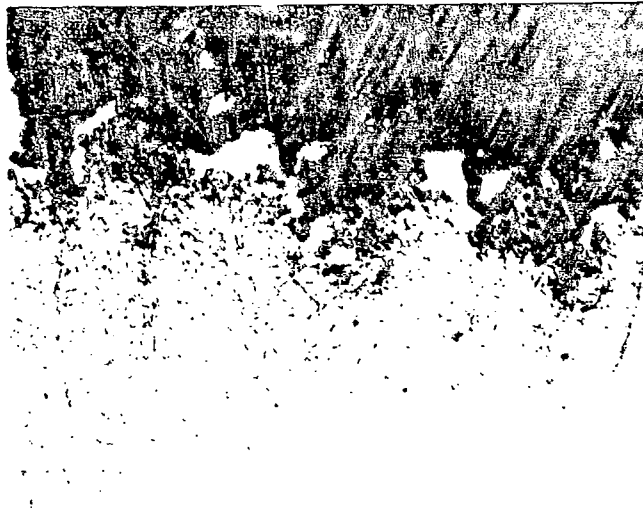
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M 4400 Molykote X-106 on A-286 Figure 259
Mag. 250X 18000x Etch: B



Severe Pitting

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M 4401 Molykote X106 on Rene 41 Figure 260
Mag: 250X 18000F Etch: C



Pitting and Chemical Corrosion

DATE

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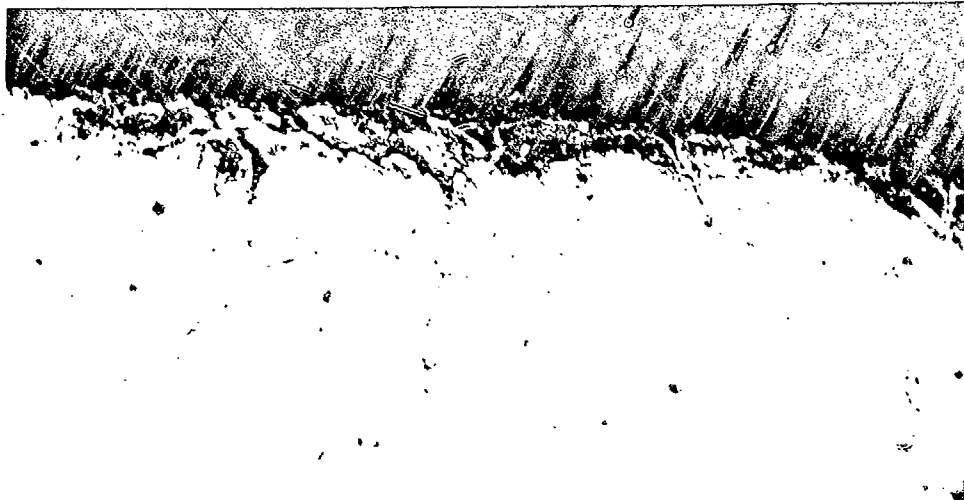
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M 4402
Mag: 250X

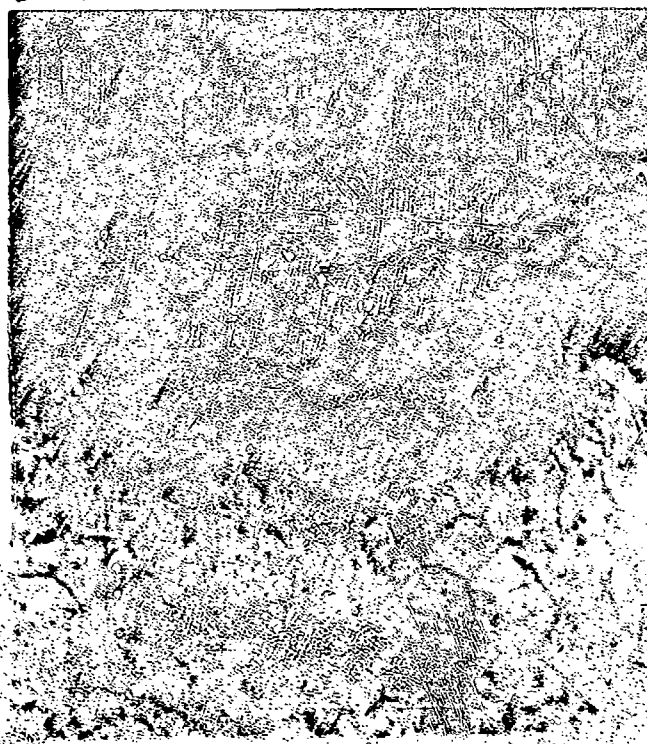
Molykote X-106 on L-605
18000P

Figure 261
Etch: C



Intergranular Attack

M 4403 Molykote X-106 on Hastelloy X Figure 262
Mag: 250X 18000P Etch: C



Intergranular Corrosion

DATE _____

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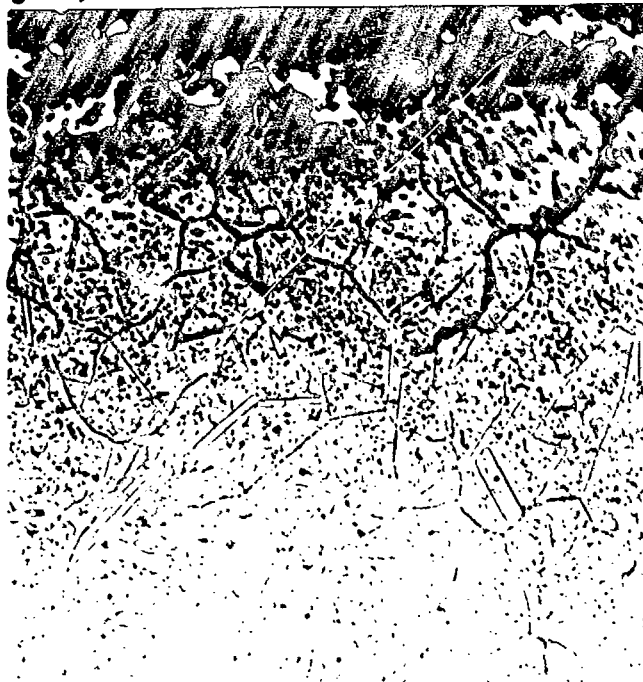
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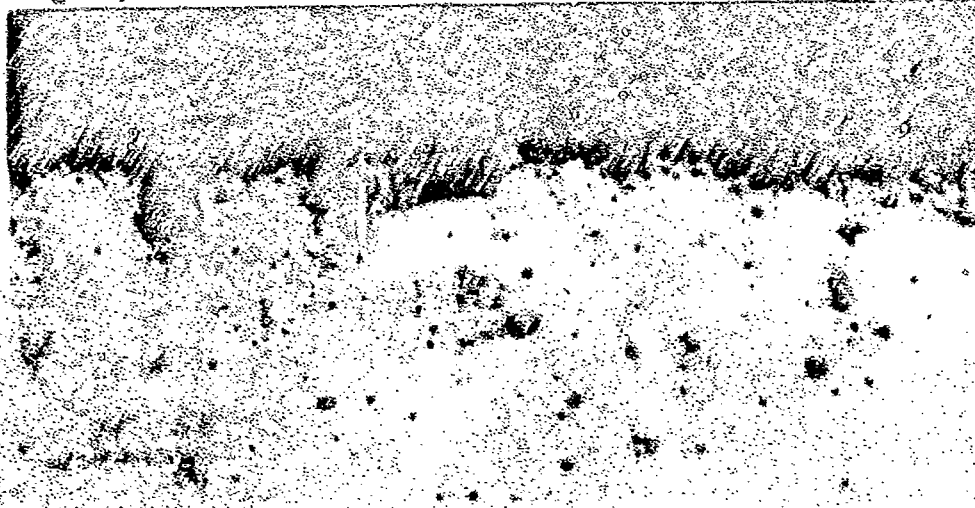
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M 4404 Molybde X-106 on 310 SS Figure 263
Mag: 250X 1800°F Etch: D



Intergranular Corrosion

M 4405 Lead Monoxide on Inconel X Figure 264
Mag: 250X 1800°F Etch: A



General Corrosion and Pitting

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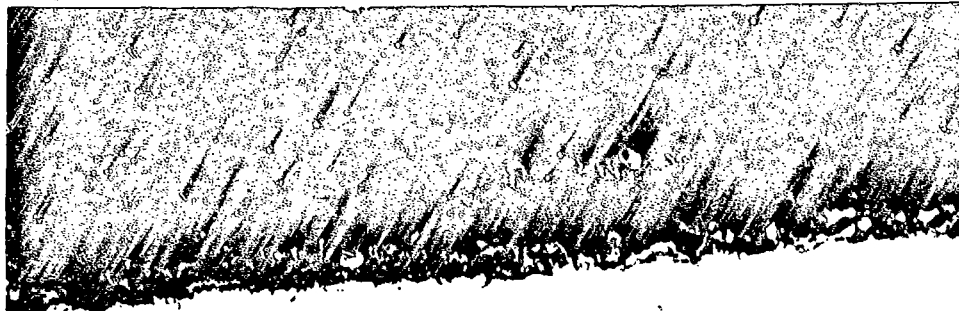
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M 4406
Mag: 250X

Lead Monoxide on A-286
1800°F

Figure 265
Etch: B



Oxidation and Pitting

M 4407
Mag: 250X

Lead Monoxide on Rene-41
1800°F

Figure 266
Etch: D



Chemical Corrosion

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M 4408
Mag: 250X

Lead Monoxide on L-605
180007

Figure 267
Btch: C



Scale Oxidation

M 4409
Mag: 250X

Lead Monoxide on Hastelloy X
180007

Figure 268
Btch: C



Oxidation

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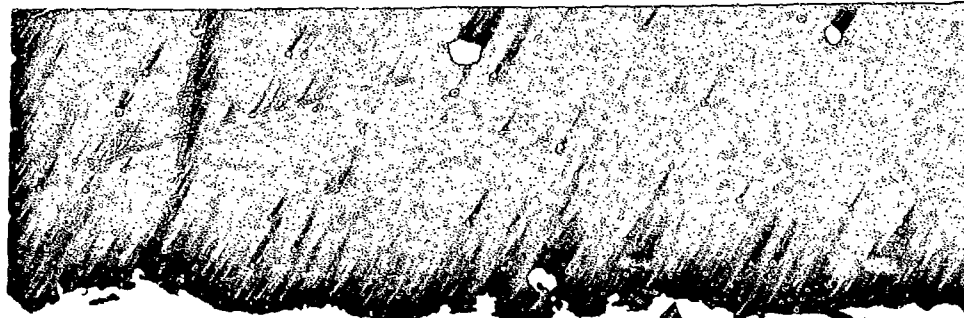
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M 4410

Lead Monoxide on 310 SS
18000 γ

Figure 269
Etch. C

Mag: 250X



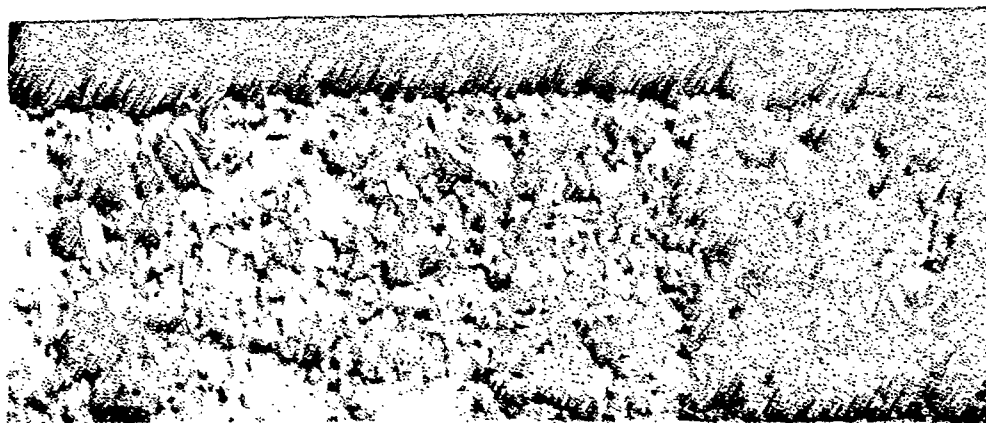
Oxidation and Pitting

M 4411

Calcium Fluoride on Inconel X
16000 γ

Figure 270
Etch: A

Mag: 250X



Pitting

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N 4412
Mag: 250X

Calcium Fluoride on A-286
1800°C

Figure 271
Etch: B



Pitting and Intergranular Oxidation

N 4413
Mag: 250X

Calcium Fluoride on René-41
1800°C

Figure 272
Etch: C



Scale Oxidation

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M 4414
Mag: 250X

Calcium Fluoride on L-605
1800°F

Figure 273
Etch: C

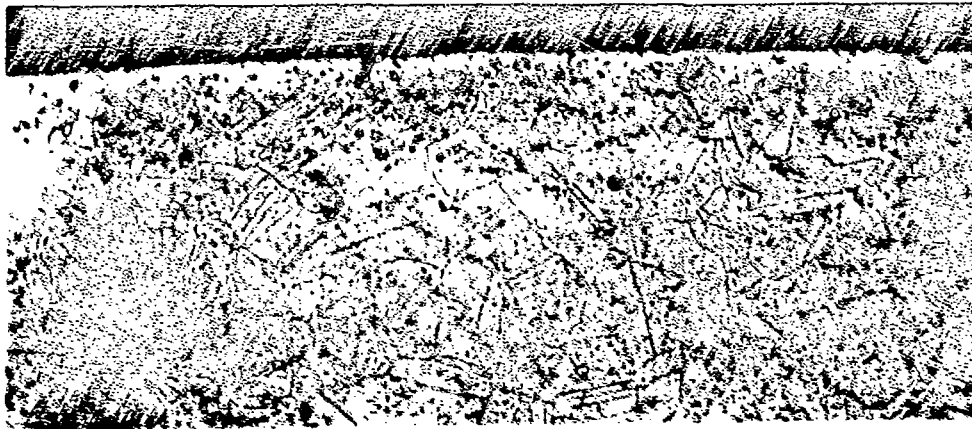


Scale Oxidation

M 4415
Mag: 250X

Calcium Fluoride on Hastelloy X
1800°F

Figure 274
Etch: C



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M 4416

Calcium Fluoride on 310 SS
18000y

Figure 275
Etch: D

Mag: 250X



Intergranular Oxidation

M 4417

Lead Sulfide on Inconel X
18000y

Figure 276
Etch: A

Mag: 250X



Extreme Corrosive Alloying

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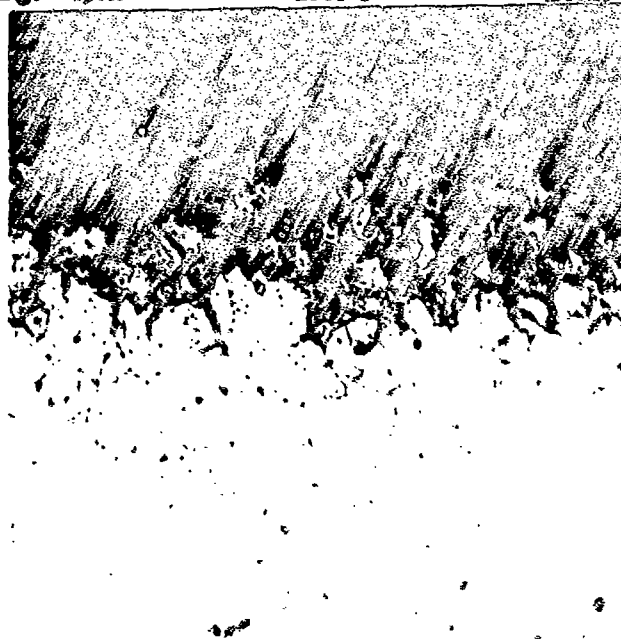
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M 4418 Lead Sulfide on A-286 Figure 277
Mag: 250X 180007 Etch: B



Extreme Corrosive Alloying

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M 4419 Lead Sulfide on Rene-41 Figure 278
Mag: 250X 1800° Etch: C



Extreme Corrosive Alloying

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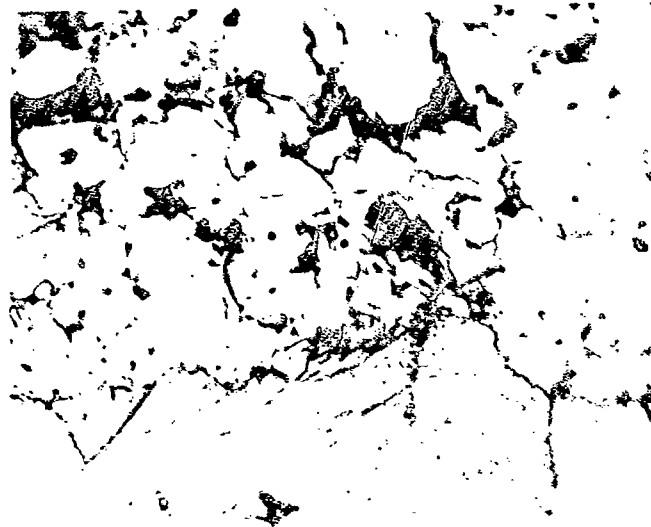
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M 4420 Lead Sulfide on L-605 Figure 279
Mag: 250X 18000p Etch: C



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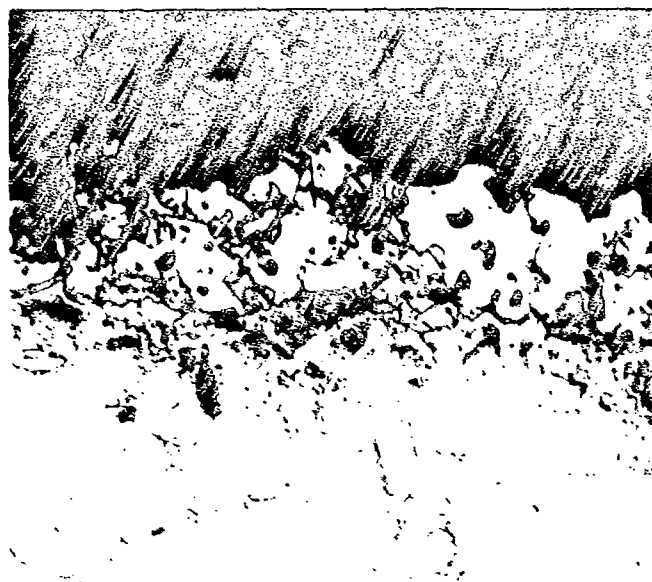
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M 4421 Lead Sulfide on Hastelloy X Figure 280
Mag: 250X 1800°F Etch: C



Extreme Corrosive Alloying

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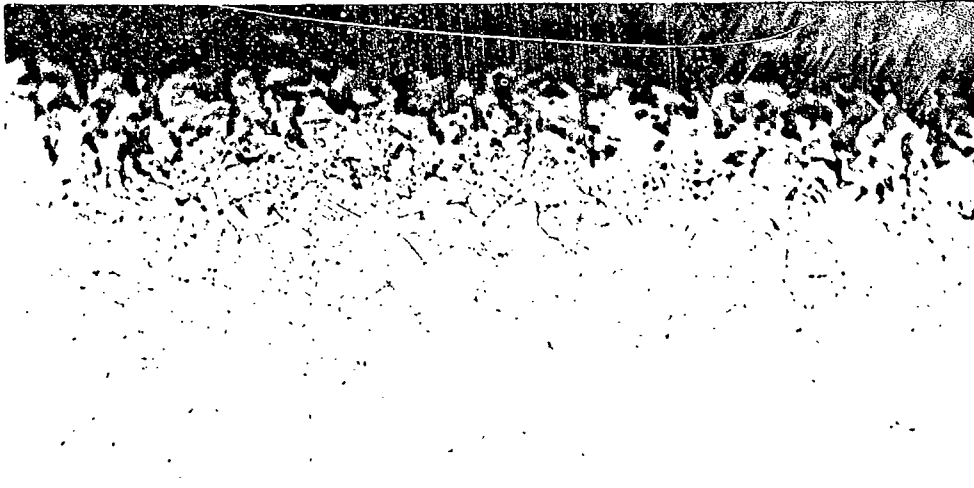
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REVISED D45-238623

M 4422
Mag: 250X

Lead Sulfide on 310 SS
1800°F

Figure 281
Etch: D



Intergranular Corrosion

M 4423
Mag: 250X

Inconel X in Air (Control Specimen) Figure 282
1800°F Etch: A



Intergranular Oxidation

DATE _____

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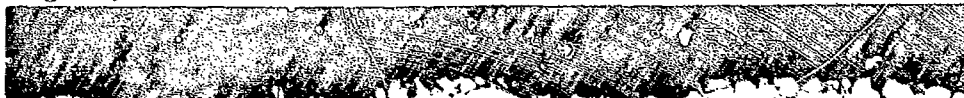
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M 4424
Mag: 250X

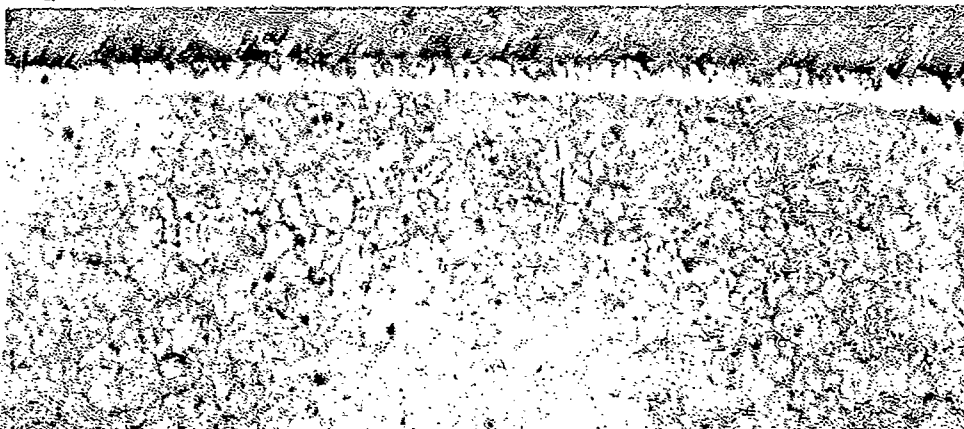
A-225 in Air (Control Specimen) Figure 283
18000p
Stch: B



Pitting and Intergranular Oxidation

M 4425
Mag: 250X

Range-41 in Air (Control Specimen) Figure 284
18000p
Stch: C



Intergranular Oxidation

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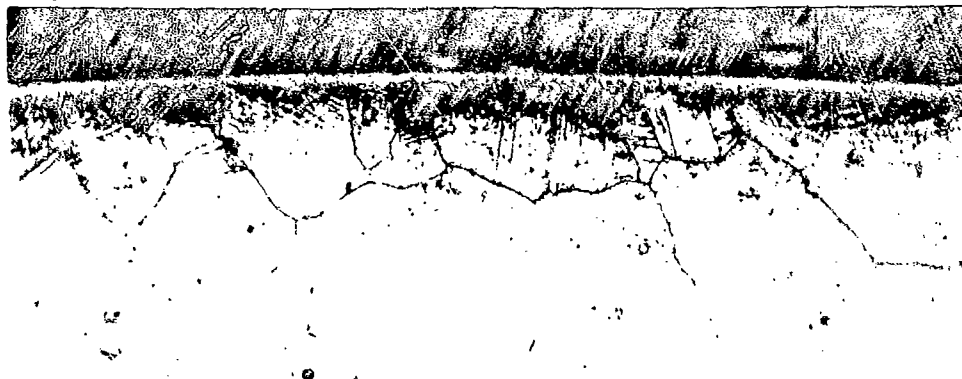
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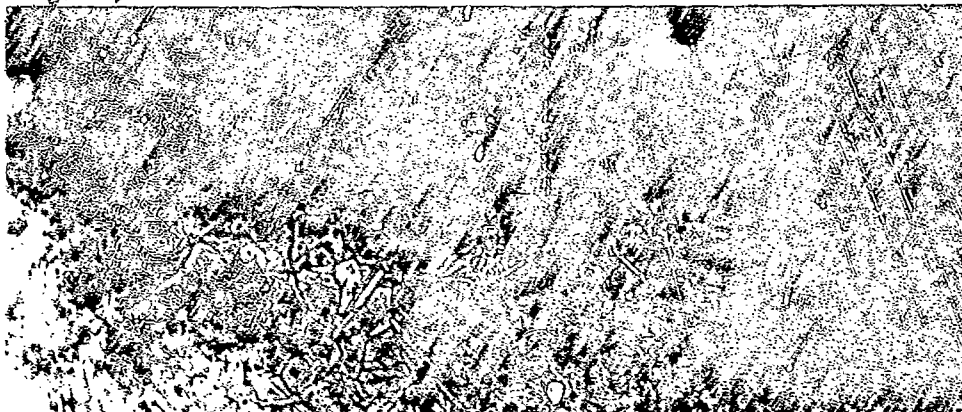
M 4426
Mag: 250X

L-605 in Air (Control Specimen) Figure 285
1800°F Etch: C



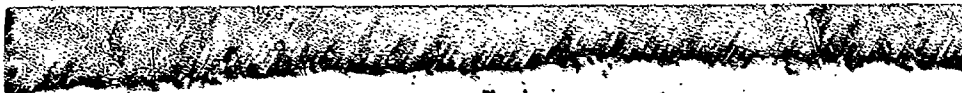
M 4427
Mag: 250X

Hastelloy X in Air (Control Specimen) Figure 286
1800°F Etch: C



M 4428
Mag: 250X

310 SS in Air (Control Specimen) Figure 287
1800°F Etch: D



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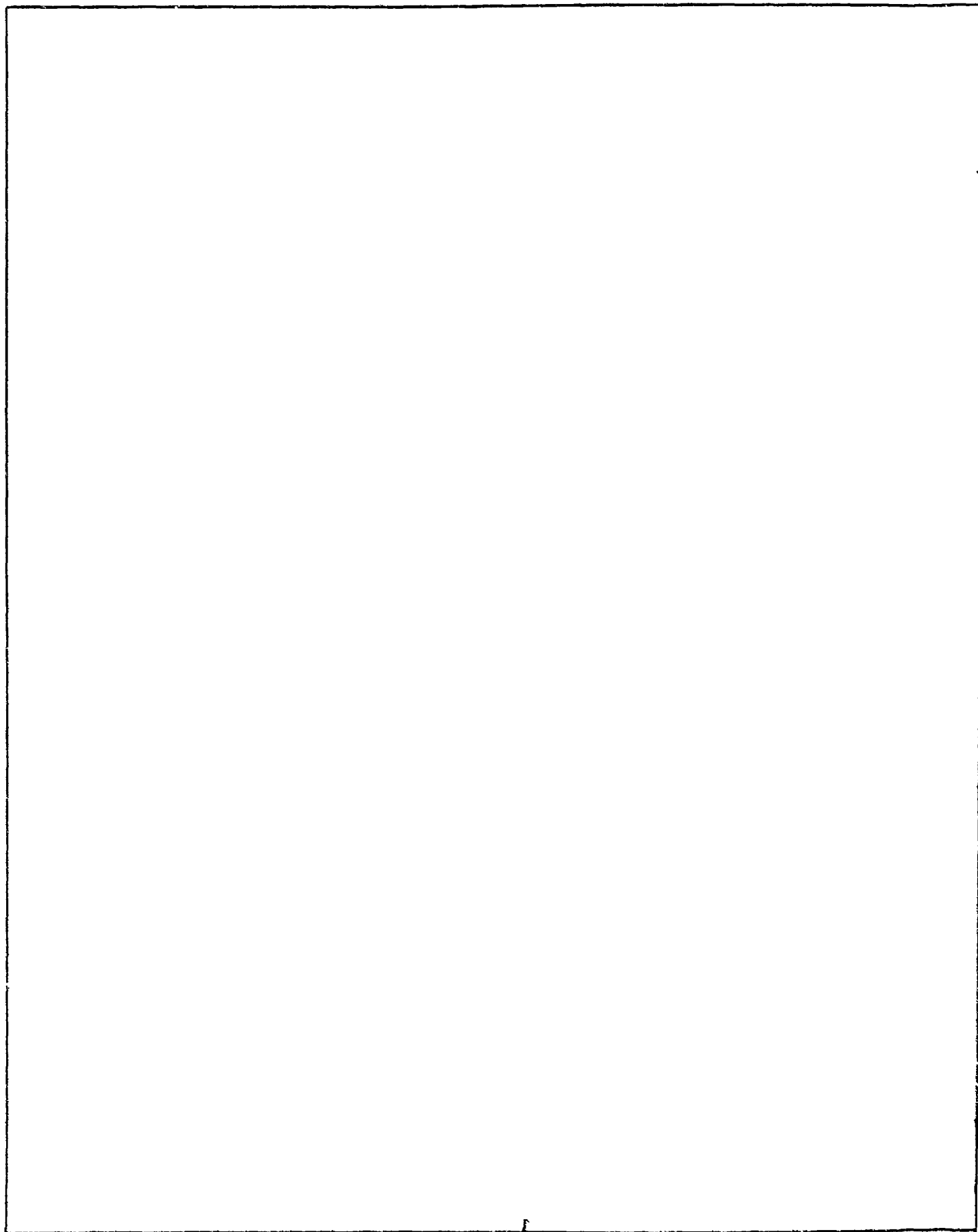
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M 4429
Mag: 500X

Silver Goop on Inconel X
1800°

Figure 288
Etch: U



Film and Intergranular Oxidation

M 4430
Mag: 500X

Silver Goop on A-286
1800°

Figure 289
Etch: U



Film and Intergranular Oxidation

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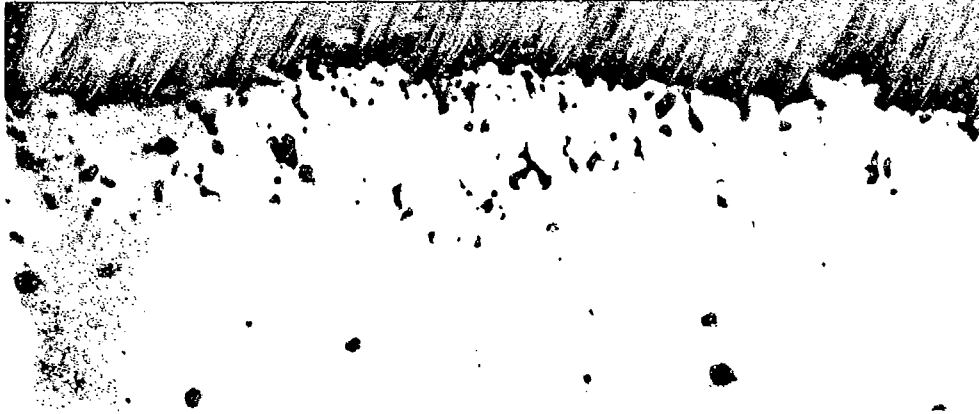
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M 4431
Mag: 500X

Silver Coop on Rene 41
18000P

Figure 290
Etch: U



Oxidation and Slight Pitting

M 4432
Mag: 500X

Silver Coop on L-603
16000P

Figure 291
Etch: U



Slight Oxidation

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M 4433
Mag: 500X

Silver Coop on Easting X
180000

Figure 292
Etch: U



M 4434
Mag: 500X

Silver Coop on Easting X

Figure 293
Etch: U



Interpretation: Silver Coop

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M 4435
Mag: 100X

Base Off 990 on Inconel X
1800°F

Figure 294
Etch: U



Extreme Oxidation, Pitting, and Corrosive Alloying

M 4436
Mag: 100X

Base Off 990 on A-306
1800°F

Figure 295
Etch: U



Severe Pitting and Chemical Corrosion

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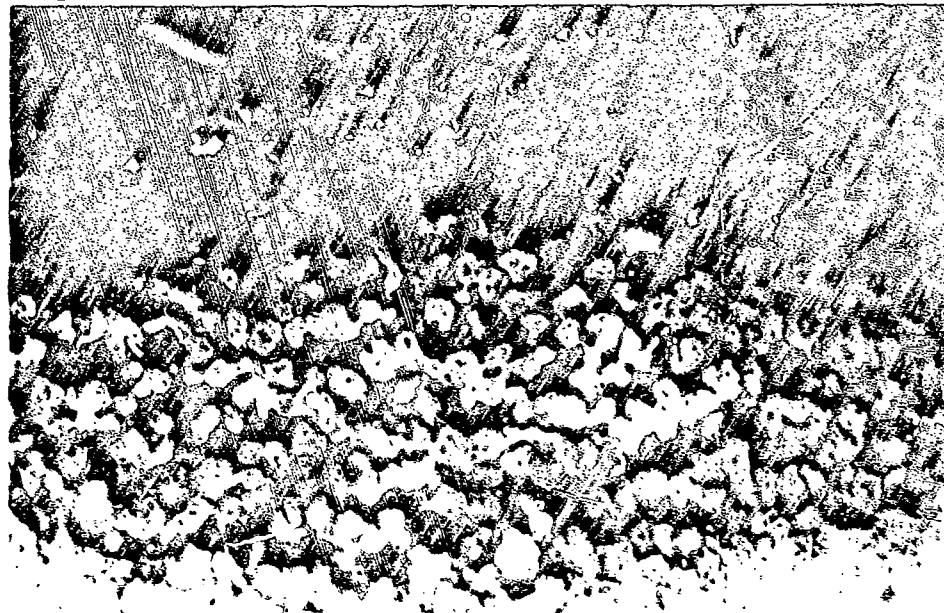
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M 4437
Mag: 250X

Ease Off 990 on Rene 41
1800°F

Figure 29c
Etch: U

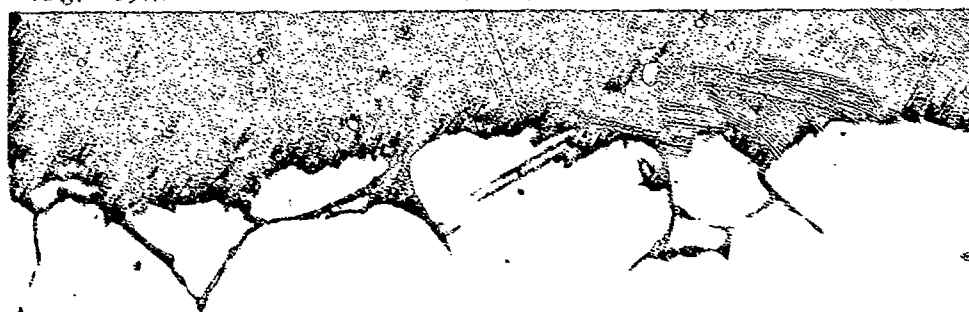


Extreme Chemical Corrosion and Corrosive Alloying

M 4438
Mag: 250X

Ease Off 990 on L-605
1800°F

Figure 29d
Etch: U



Intergranular Attack

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M 4439
Mag: 100X

Ease Off 990 on HastelloyX
1800°F

Figure 298
Etch: U

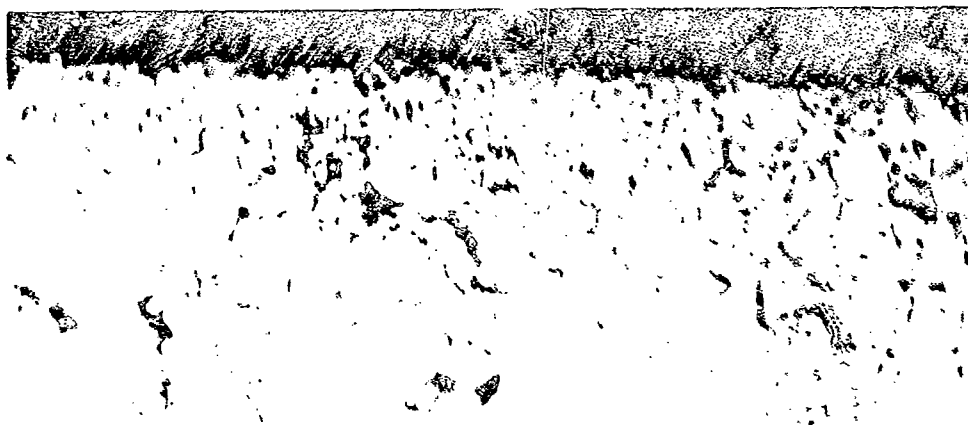


Extreme Pitting and Corrosive Alloying

M 4440
Mag: 250X

Ease Off 990 on 310 SS
1800°F

Figure 299
Etch: U



Severe Intergranular Corrosion

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M 4441

Fel. Pro. 65-A on Inconel X
1800°F

Figure 300
Etch: U

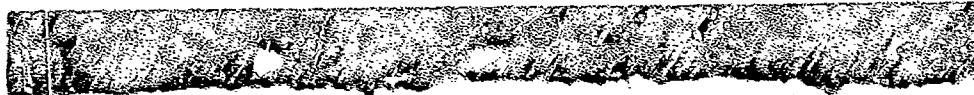


Intergranular Oxidation

M 4442

Fel. Pro. 65-A on A-286
1800°F

Figure 301
Etch: U



Intergranular Oxidation

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M 4443
Mag: 500X

Fel. Pro. 65-A on René-41
1800°F

Figure 302
Etch: U

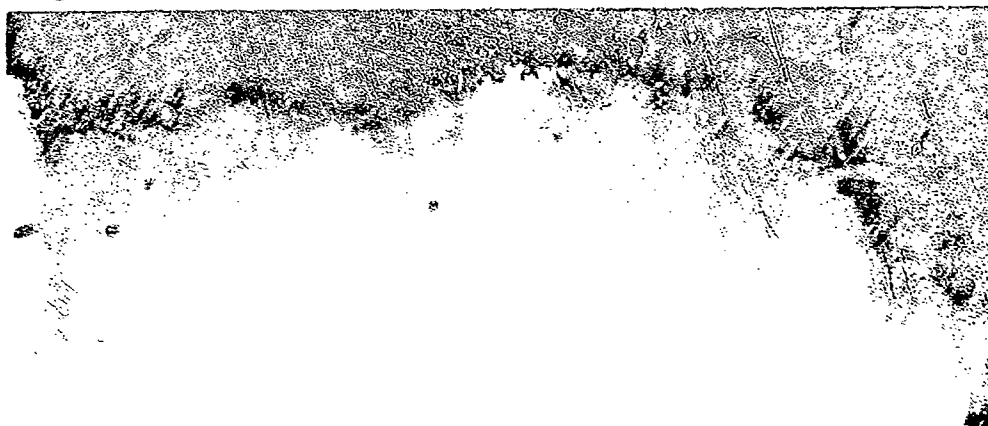


Oxidation

M 4444
Mag: 500X

Fel. Pro. 65A on L-605
1800°F

Figure 303
Etch: U



Oxidation and Slight Pitting

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M 4445

Fel. Pro. 65-A on Hastelloy X
1800°F

Figure 304

Mag: 500X

Etch: U



Slight Oxidation

M 4446

Fel. Pro. 65-A on 310 SS
1800°F

Figure 305

Mag: 500X

Etch: U



Oxidation and Slight Pitting

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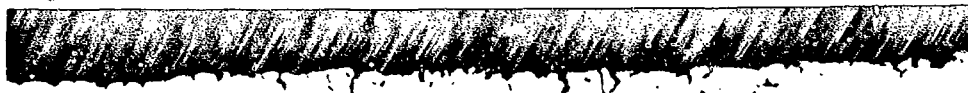
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M 4447
Mag: 500X

DGF 123 on Inconel X
1800°F

Figure 306
Etch: U



Slight Oxidation

M 4448
Mag: 250X

DGF 123 on 2-225
1800°F

Figure 307
Etch: U



Oxidation

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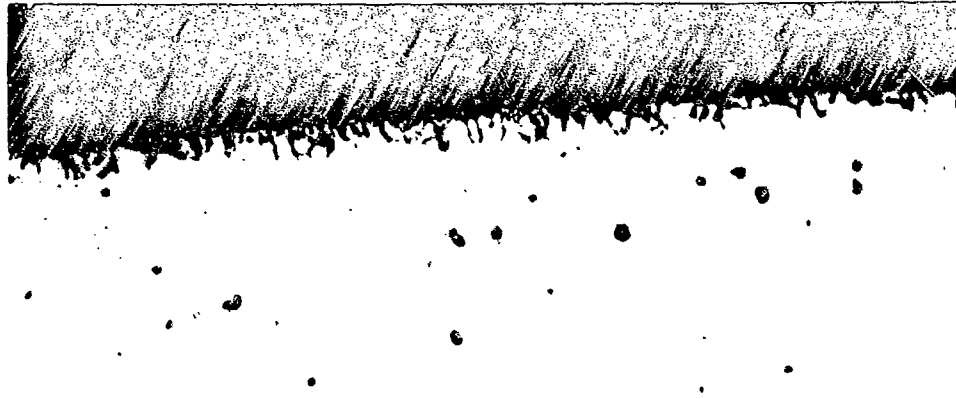
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M 4449
Mag: 500X

DOF 123 on Rene'41
18000F

Figure 308
Etch: U



Film and Slight Intergranular Oxidation

M 4450
Mag: 500X

DOF 123 on L-605
18000F

Figure 309
Etch: U



Slight Oxidation

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M 4451
Mag: 500X

DGF 123 on Eastalloy X
1800°F

Figure 310
Etch: U



Film Oxidation and Slight Pitting

M 4452
Mag: 500X

DGF 123 on 310 SS
1800°F

Figure 311
Etch: U



Slight Oxidation

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M 4453

MIL-T-5544-A on Inconel X
1800°F

Figure 12
Etch: U



Oxidation and Slight Intergranular Attack

M 4454

MIL-T-5544-A on A-286
1800°F

Figure 13
Etch: U



Oxidation and Slight Pitting

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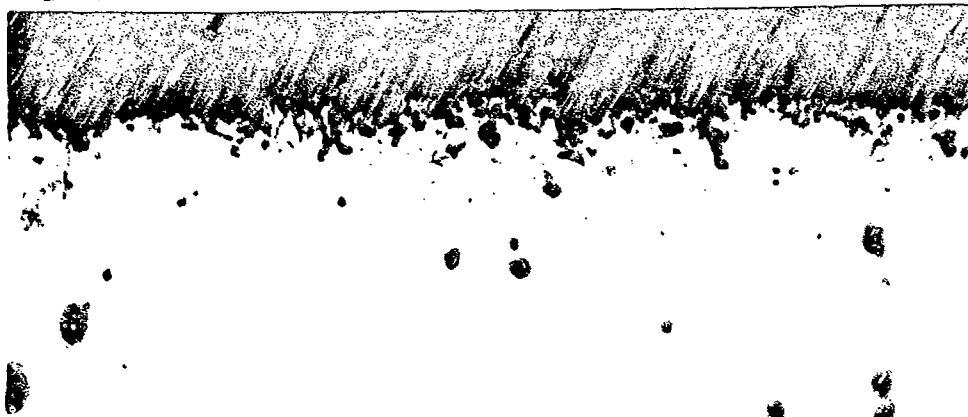
M 4455

MIL-T-5544-A on René-41
18000p

Figure 314

Mag: 500X

Etch: U



Oxidation and Pitting

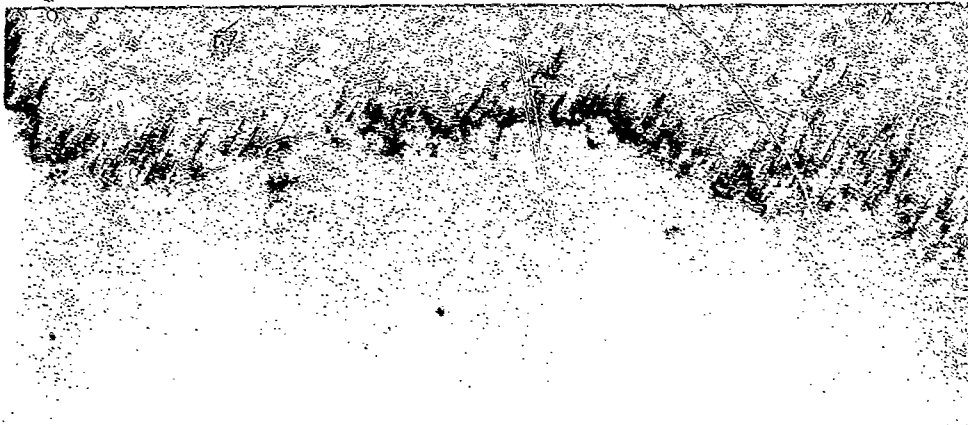
M 4456

MIL-T-5544-A on L-605
18000p

Figure 315

Mag: 500X

Etch: U



Film Oxidation and Slight Pitting

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M 4457

MIL-T-5544-A on Hastelloy X
1800°F

Figure 316
Etch: U



Film Oxidation

M 4458

MIL-T-5544-A on 310 SS
1800°F

Figure 317
Etch: U



Film Oxidation

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M 4459

Electrofilm 1000 on Inconel X
18000X

Figure 318

Mag: 500X

Etch: U



Oxidation and Pitting

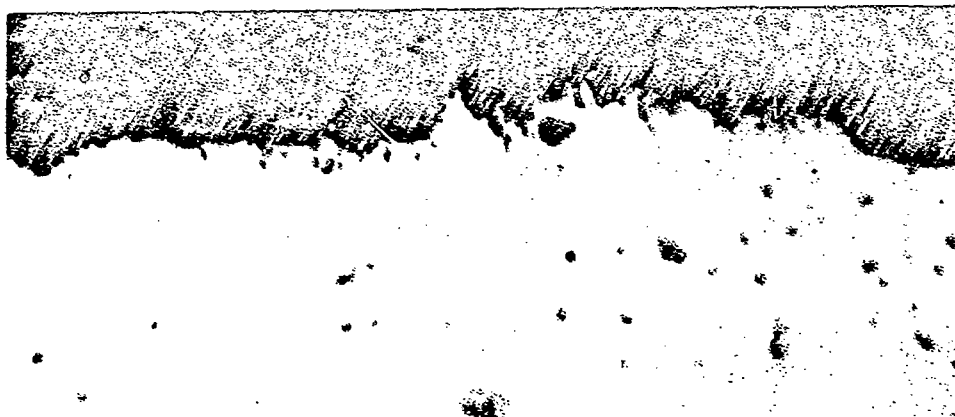
M 4460

Electrofilm 1000 on A-286
18000X

Figure 319

Mag: 500X

Etch: U



Pitting

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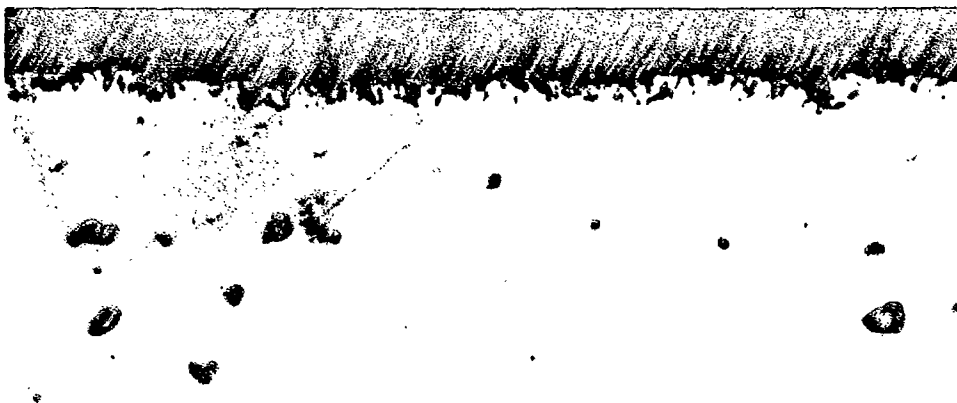
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M 4461
Mag: 500X

Electrofilm 1000 on Rene-41
18000 ϕ

Figure 320
Etch: U

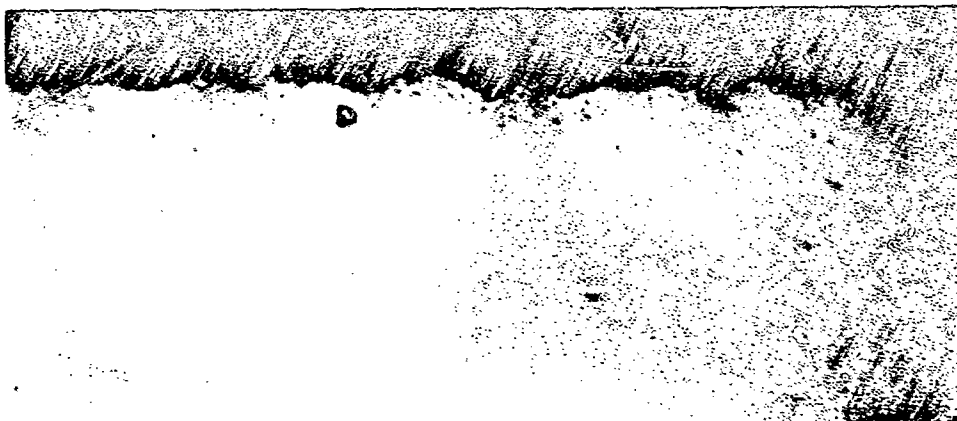


Oxidation and Slight Pitting

M 4462
Mag: 500X

Electrofilm 1000 on L-605
18000 ϕ

Figure 321
Etch: U



Oxidation and Slight Pitting

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M 4463
Mag: 500X

Electrofilm 1000 on Hastalloy X
18000P

Figure 322
Etch: U



Pitting

M 4464
Mag: 500X

Electrofilm 1000 on 310 SS
18000P

Figure 323
Etch: U



Light Pitting on Hastalloy X

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M 4465
Mag: 500X

Electrofilm 1005 on Inconel X
1800°F

Figure 324
Etch: U

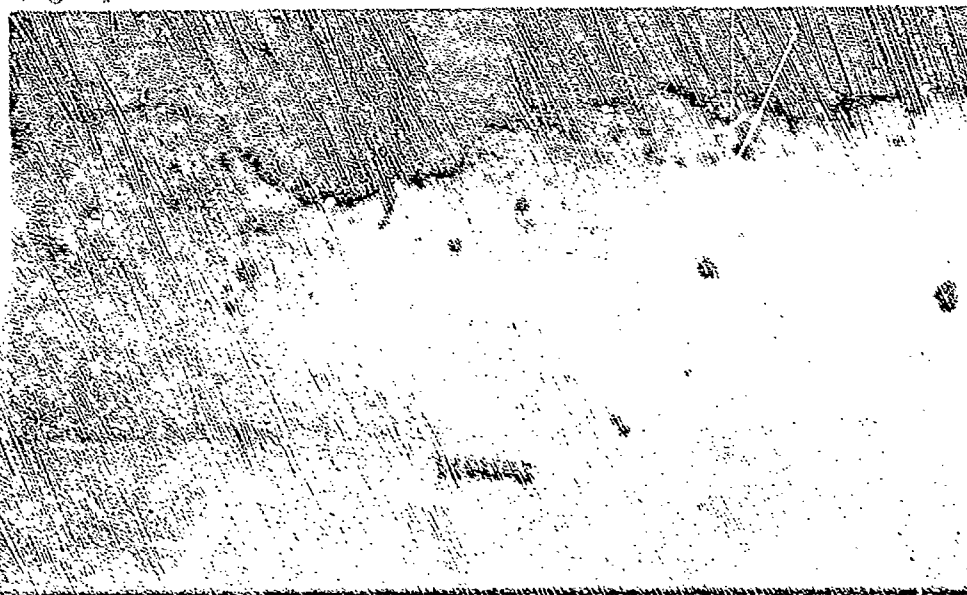


Slight Pitting and Intergranular Attack

M 4466
Mag: 500X

Electrofilm 1005 on A-286
1800°F

Figure 325
Etch: U



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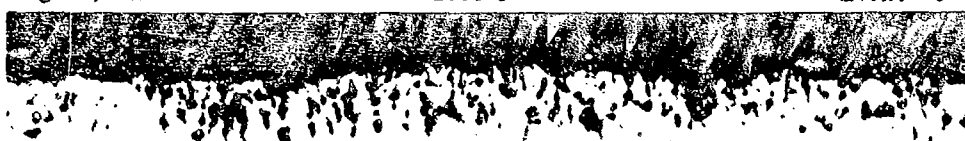
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M 4467

Electrofilm 1005 on Kene-41
180007

Figure 326
Etch: U



Oxidation and Slight Pitting

M 4468

Electrofilm 1005 on L-605
180007

Figure 327
Etch: U



Slight Oxidation

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M 4464
Mag: 500X

Electrofilm 1005 on Hastelloy X
18000P

Figure 328
Etch: U



Slight Oxidation

M 4470
Mag: 500X

Electrofilm 1005 on 31.0 SS
18000P

Figure 330
Etch: U



Slight Intergranular Oxidation and Pitting

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M 4471
Mag: 500X

Electrofilm 2007 on Inconel X
18000F

Figure 330
Etch: U



Slight Intergranular Oxidation

M 4472
Mag: 500X

Electrofilm 2007 on A-286
18000F

Figure 331
Etch: U



Pitting

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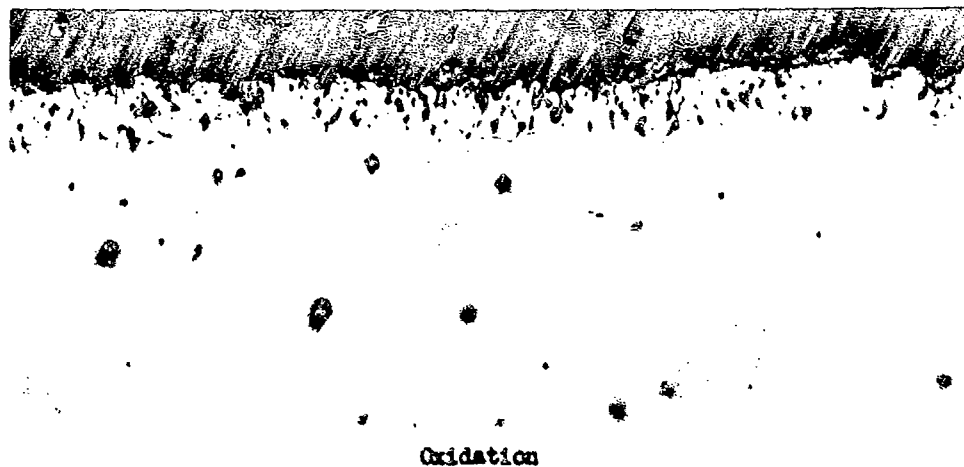
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M 4473
Mag: 500X

Electrofilm 2007 on René-41
18000°F

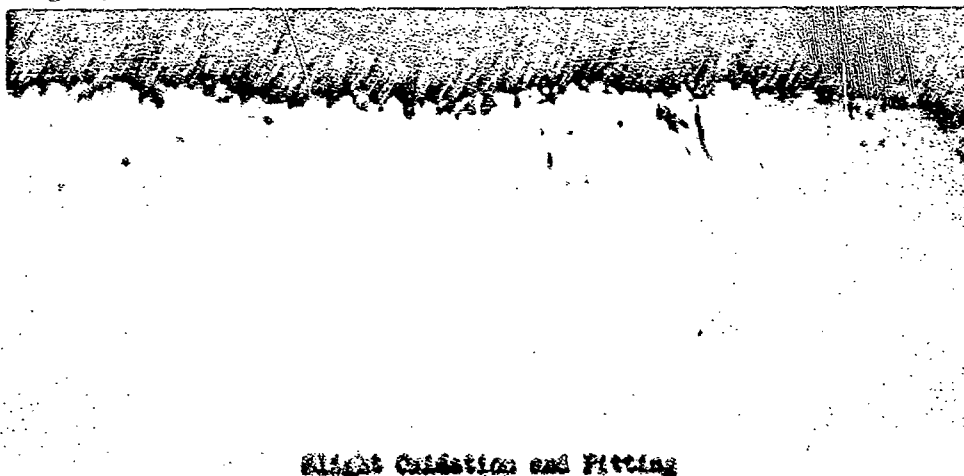
Figure 332
Etch: U



M 4474
Mag: 500X

Electrofilm 2007 on L-605
18000°F

Figure 333
Etch: U



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M 4475
Mag: 500X

Electrofilm 2007 on Hastelloy X
1800°F

Figure 334
Etch: U



Pitting

M 4475
Mag: 500X

Electrofilm 2007 on 310 SS
1800°F

Figure 334
Etch: U



Pitting

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M 4477
Mag: 500X

Electrofilm 66C on Inconel X
18000F

Figure 336
Etch: U

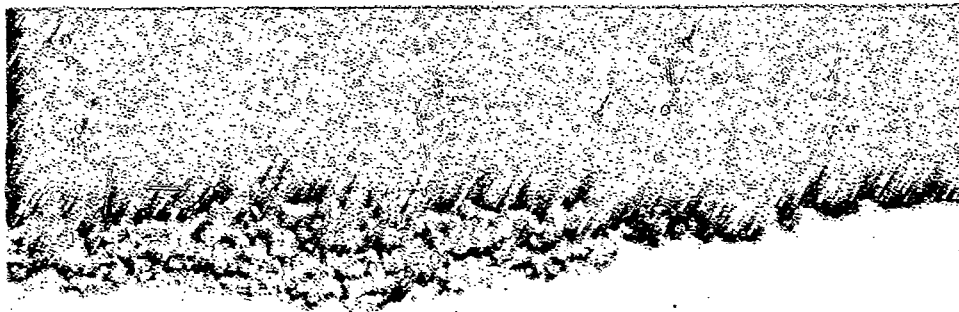


Slight Intergranular Oxidation and Pitting

M 4478
Mag: 500X

Electrofilm 66C on A-286
18000F

Figure 337
Etch: U



Pitting

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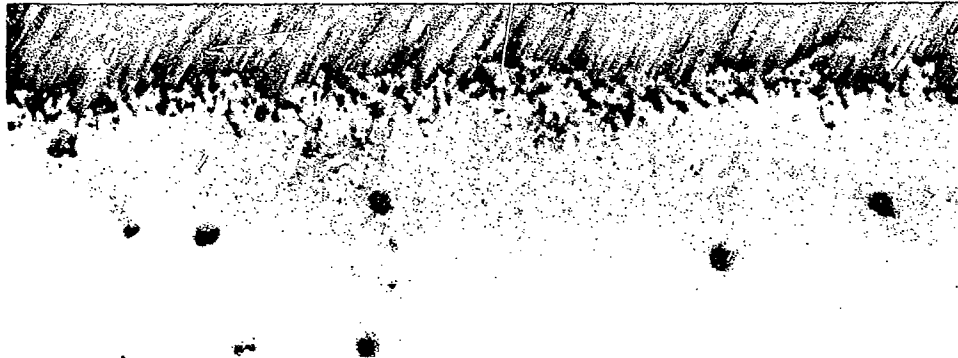
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M 4479

Electrofilm 66C on Rene-41
1800°P

Figure 338
Etch: U

Mag: 500X



Oxidation

M 4480

Electrofilm 66C on L-605
1800°P

Figure 339
Etch: U

Mag: 500X



Light Oxidation and Pitting

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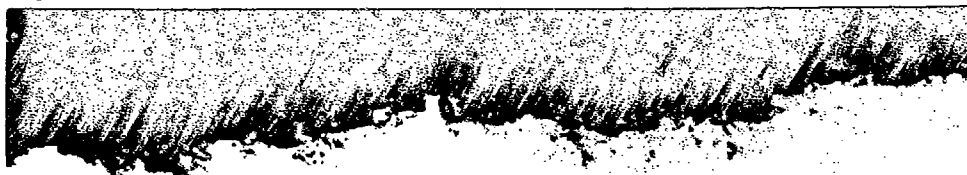
M 4481

Mag: 500X

Electrofilm 66C on Hastalloy X
18000F

Figure 340

Etch: U



Oxidation and Slight Pitting

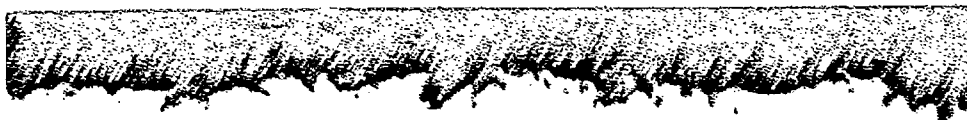
M 4482

Mag: 500X

Electrofilm 66C on 310 SS
18000F

Figure 341

Etch: U



Slight Oxidation and Pitting

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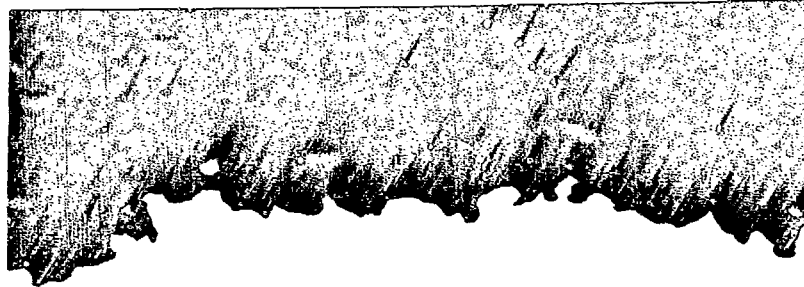
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M 4483
Mag: 50X

Phosphatherm RN on Inconel X
1800°F

Figure 342
Etch: U



Extreme Pitting and Corrosive Alloying

M 4484
Mag: 100X

Phosphatherm RN on A-366
1800°F

Figure 343
Etch: U



Extreme Corrosive Alloying and Pitting

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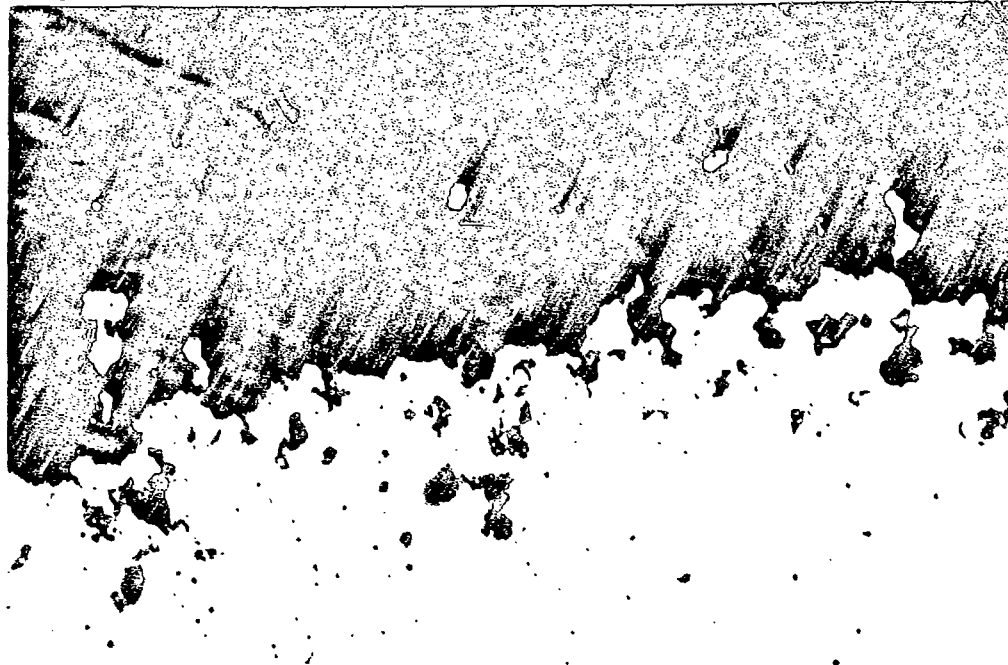
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M 4485

Phosphatherm RN on René-41
18000P

Figure 344
Etch: U

Mag: 100X



Extreme Chemical Corrosion and Corrosive Alloying

M 4486

Phosphatherm RN on L-605
18000P

Figure 345
Etch: U

Mag: 500X



Severe Chemical Corrosion

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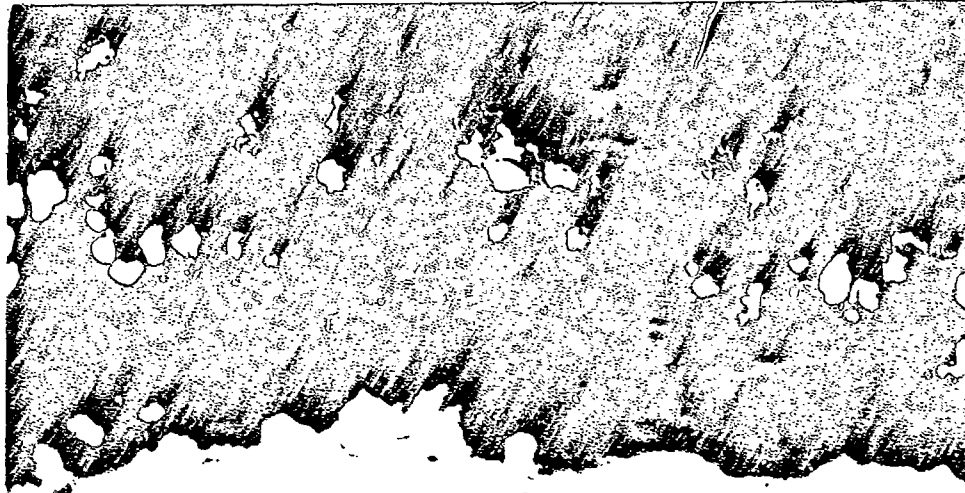
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M 4487

Phosphatherm RN on Hastelloy X
18000F

Figure 3-4
Etch: U

Mag: 100X



Extreme Chemical Corrosion and Corrosive Alloying

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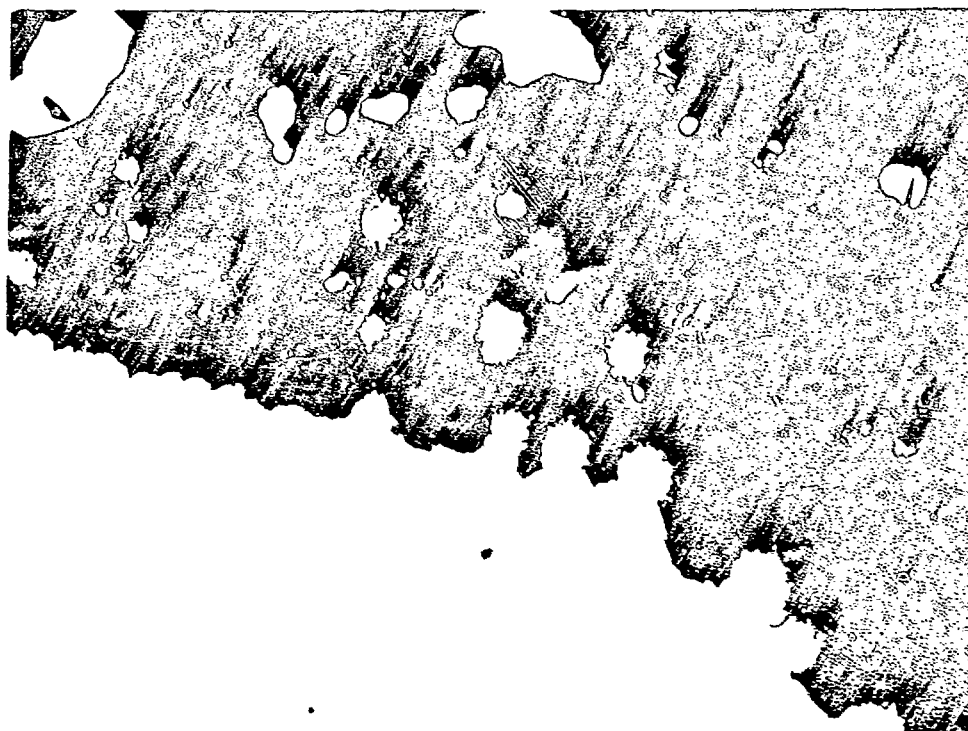
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M. 4488

Mag: 100X

Phosphatherm RN on 310 SS
18000F

Figure 347
Etch: U



Extreme Pitting and Corrosive Alloying

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M. 1000

Sodium Silicate on Inconel X
1800°F

Figure 140
Etch:

Map: 100X



Pitting

Sodium Silicate on Inconel X
1800°F

Figure 141
Etch:



Pitting and Slight Intergranular Attack

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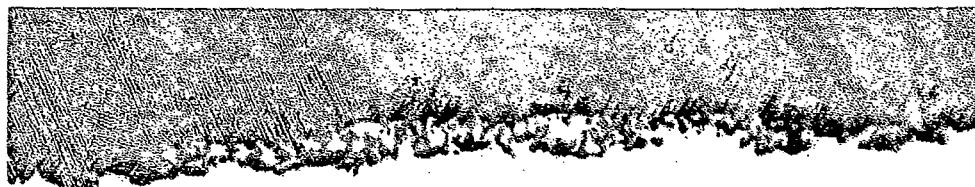
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M 4491
Mag: 500X

Sodium Silicate on René 41
1800°F

Figure 350
Etch: U



Slight Intergranular Attack

M 4492
Mag: 500X

Sodium Silicate on L-605
1800°F

Figure 351
Etch: U



PLATE 16

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M 4493
Mag: 500X

Sodium Silicate on Hastelloy' X
1800°F

Figure 352
Etch: U

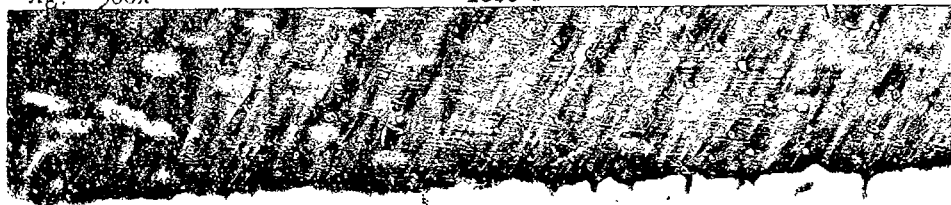


Slight Pitting

M 4494
Mag: 500X

Sodium Silicate on 310 SS
1800°F

Figure 353
Etch: U



Pitting

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M 4495
Mag: 500X

Silica on Inconel X
1800°F

Figure 354
Etch: U



Slight Intergranular Oxidation

M 4496
Mag: 500X

Silica on A-286
1800°F

Figure 355
Etch: U



Pitting

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M 4497
Mag: 500X

Silica on Rene 41
1800°F

Figure 356
Etch: U



Oxidation Pitting

M 4498
Mag: 500X

Silica on L-605
1800°F

Figure 357
Etch: U



Slight Oxidation

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M 4499
Mag: 500X

Silica on Hastelloy X
1800°F

Figure 353
Etch: U

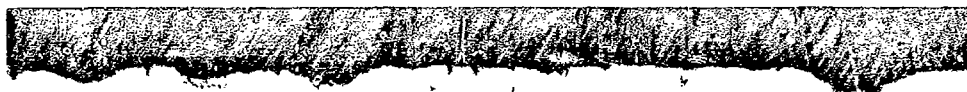


Slight Oxidation

M 4500
Mag: 500X

Silica on 310 SS
1800°F

Figure 359
Etch: U



Slight Pitting and Intergranular Attack

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M 4501
Mag: 500X

Milk of Magnesia on Inconel X
1800°F

Figure 360
Etch: U



Film and Intergranular Oxidation

M 4502
Mag: 500X

Milk of Magnesia on A-286
1600°F

Figure 361
Etch: U



Pitting

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M 4503
Mag: 500X

Milk of Magnesia on Rene 41
1800°F

Figure 362
Etch: U



Oxidation

M 4504
Mag: 500X

Milk of Magnesia on L-605
1800°F

Figure 363
Etch: U



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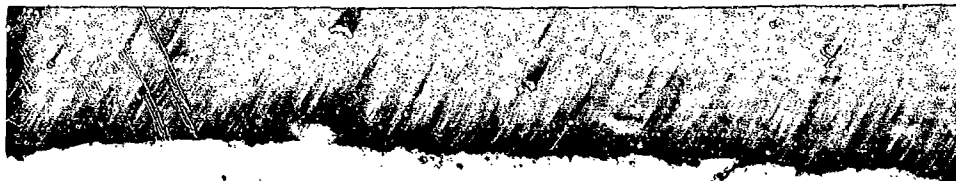
REPORT A978

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M 4505
Mag: 500X

Milk of Magnesia on Hastelloy, X
1800°C

Figure 364
Etch: U



M 4506
Mag: 500X

Milk of Magnesia on 320 SS
1800°C

Figure 269
Etch: U



Flight Evaluation and Filing

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M 4507

Magnesium Oxide on Inconel X

Figure 366

Mag: 500X

1800°F

Etch: U



Oxidation and Pitting

M 4508

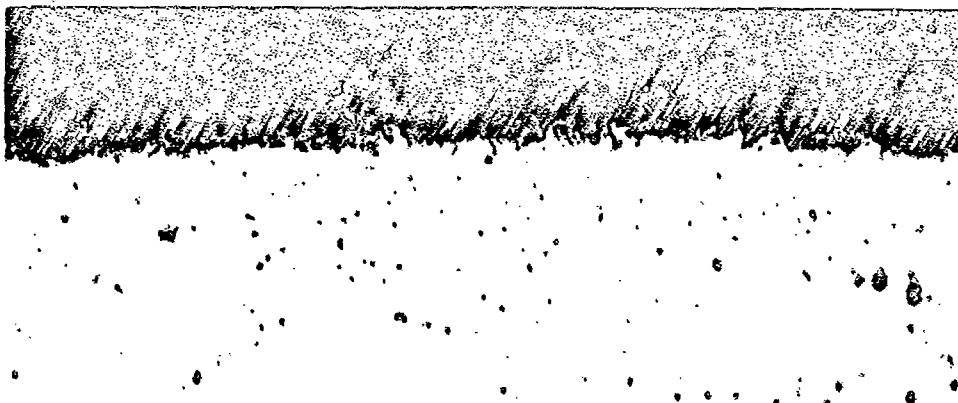
Magnesium Oxide on A-286

Figure 367

Mag: 500X

1800°F

Etch: U



Oxidation

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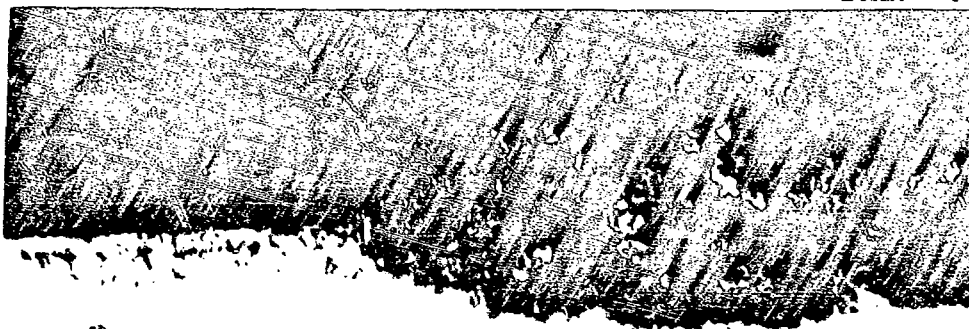
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M 4509
Mag: 500X

Magnesium Oxide on René 41
1800°P

Figure 368
Etch: U

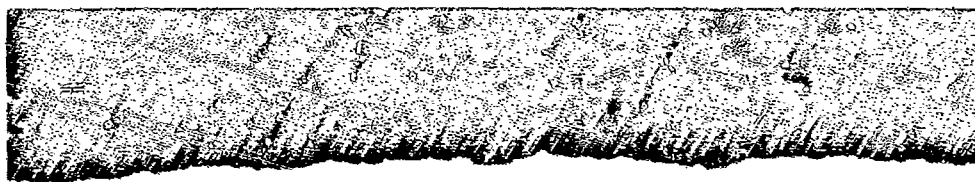


Oxidation and Pitting

M 4510
Mag: 250X

Magnesium Oxide on L-605
1800°P

Figure 369
Etch: U



Scale Oxidation

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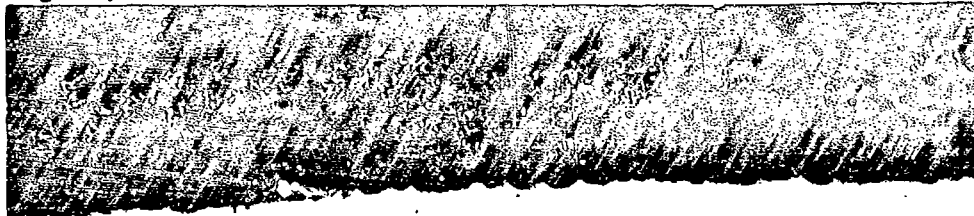
M 4511

Magnesium Oxide on Hastalloy X
1800°

Figure 370

Mag: 250X

Etch: U



Etch: Oxidation

M 4512

Magnesium Oxide on 310 SS
1800°

Figure 371

Mag: 500X

Etch: U



Oxidation and Etch: Striking

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M 4513

Boron Nitride On Inconel X

Figure 372

Mag: 500X

1800 F

Etch: U



Slight Pitting and Intergranular Oxidation

M 4514

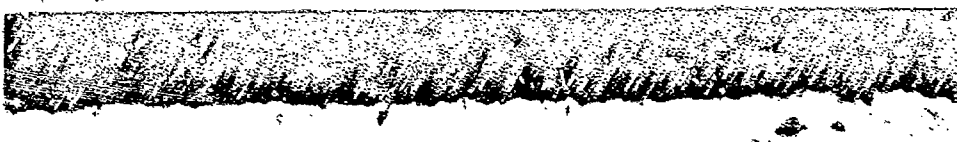
Boron Nitride On A-535

Figure 373

Mag: 500X

1800 F

Etch: U



Slight Oxidation and Pitting

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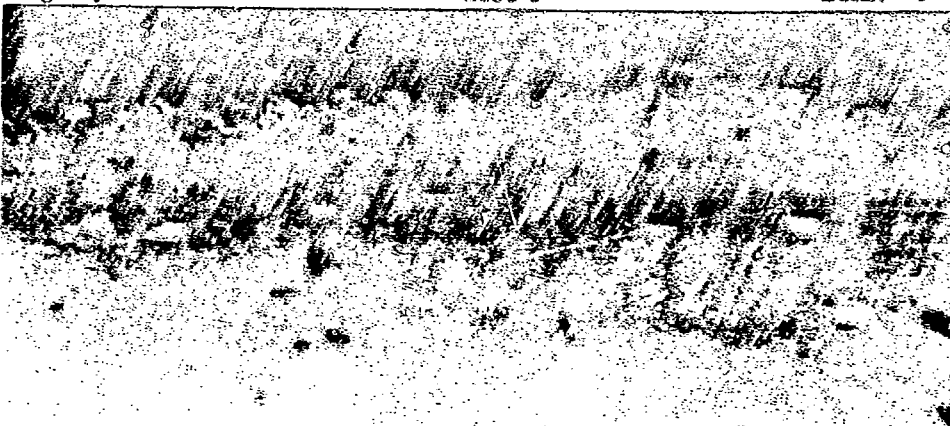
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N 4515

Boron Nitride on Base 41
1600°

Figure 376
Etch: U



Corrosion

N 4516

Boron Nitride on L-40
1600°

Figure 379
Etch: U



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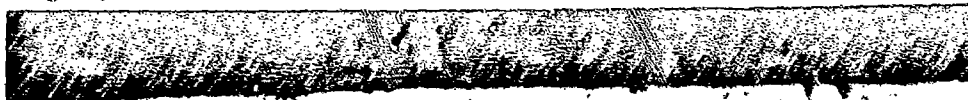
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N 4517
Mag: 500X

Boron Nitride on Hastelloy X
1800°F

Figure 376
Etch: U



Single Crystalline

N 4518
Mag: 500X

Boron Nitride on Inconel 600
1800°F

Figure 377
Etch: U



Single Crystalline

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M 429
Mag: 500X

Boric Oxide on Inconel X
1600°F

Figure 378
ETCH: U



Intergranular Oxidation

M 4520
Mag: 500X

Boric Oxide on A-286
1600°F

Figure 379
ETCH: U



211-021 000-000-000

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M 4521
Mag: 500X

Boric Oxide on Rene 41
1800°F

Figure 380
Etch: U

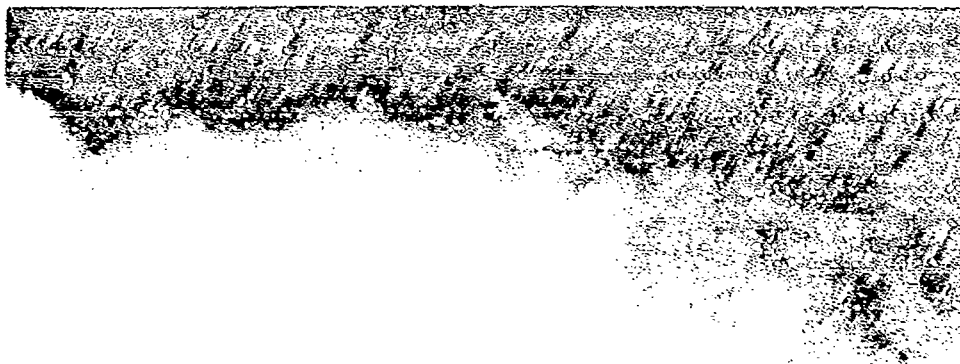


Slight Oxidation

M 4522
Mag: 500X

Boric Oxide on L-605
1800°F

Figure 381
Etch: U



Slight Oxidation

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M 4523

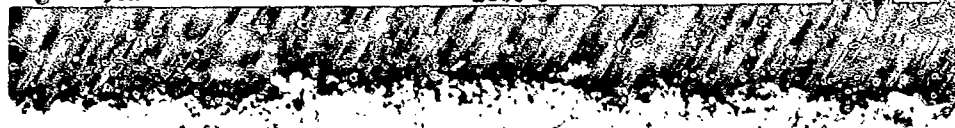
Boric Oxide on Hastelloy X

Figure 382

Mag: 250X

1800°F

Etch: II



Intergranular Attack

M 4524

Boric Oxide on 310 SS

Figure 383

Mag: 250X

1800°F

Etch: II



Intergranular Corrosion

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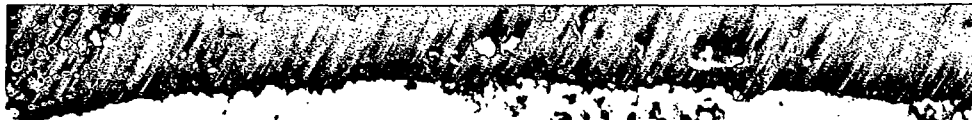
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M 4525
Mag: 100X

Molykote X-106 on Inconel X
1800° F

Figure 384
Etch: U



Intergranular Attack

M 4526
Mag: 100X

Molykote X-106 on A-286
1800° F

Figure 385
Etch: U



Severe Pitting

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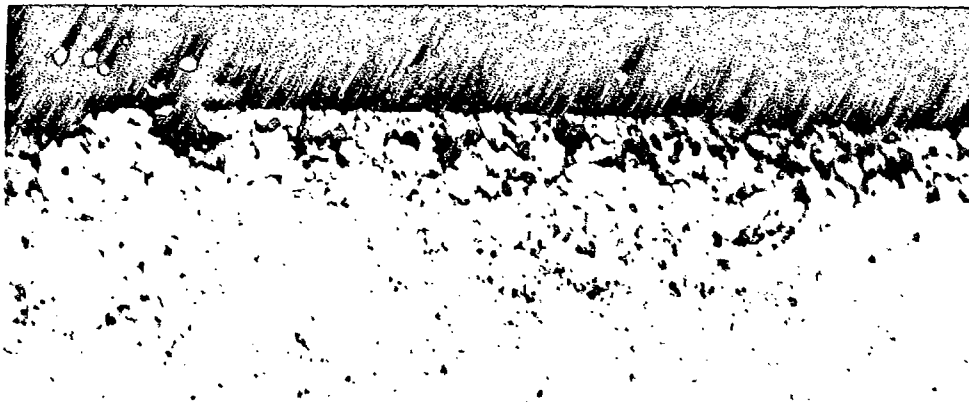
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M 4527
Mag: 250X

Molykote X-106 on Rene 41
1800°F

Figure 386
Etch: U



Pitting and Chemical Corrosion

M 4528
Mag: 250X

Molykote X-106 on L-605
1800°F

Figure 387
Etch: U



Intergranular Attack

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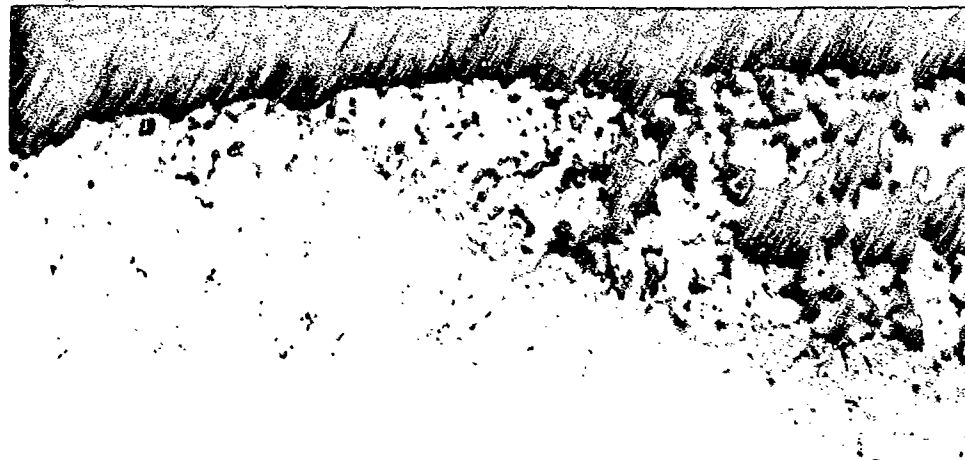
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M 4529
Mag: 250X

Molykote X-106 on Hastelloy X
1800°F

Figure 368
Etch: U

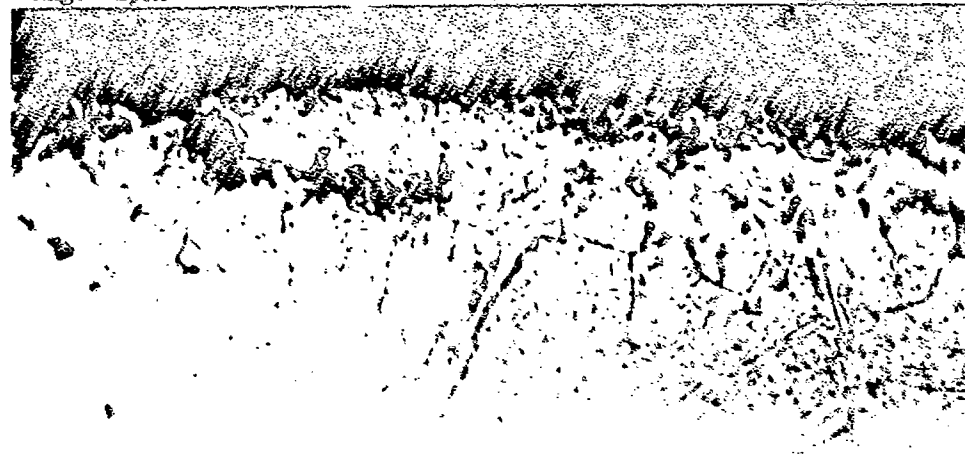


Intergranular Attack and Corrosive Alloying

M 4530
Mag: 250X

Molykote X-106 on 310 SS
1800°F

Figure 369
Etch: U



Intergranular Corrosion

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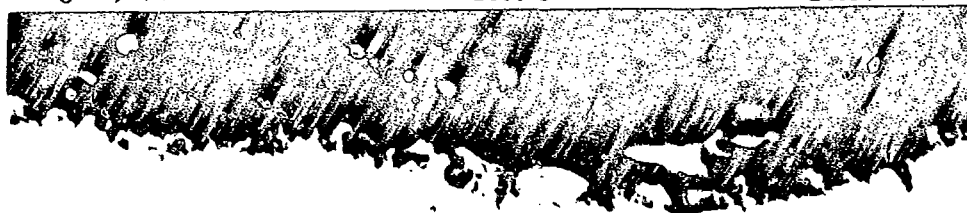
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M 4531
Mag: 500X

Lead Monoxide on Inconel X
1800°F

Figure 390
Etch: U

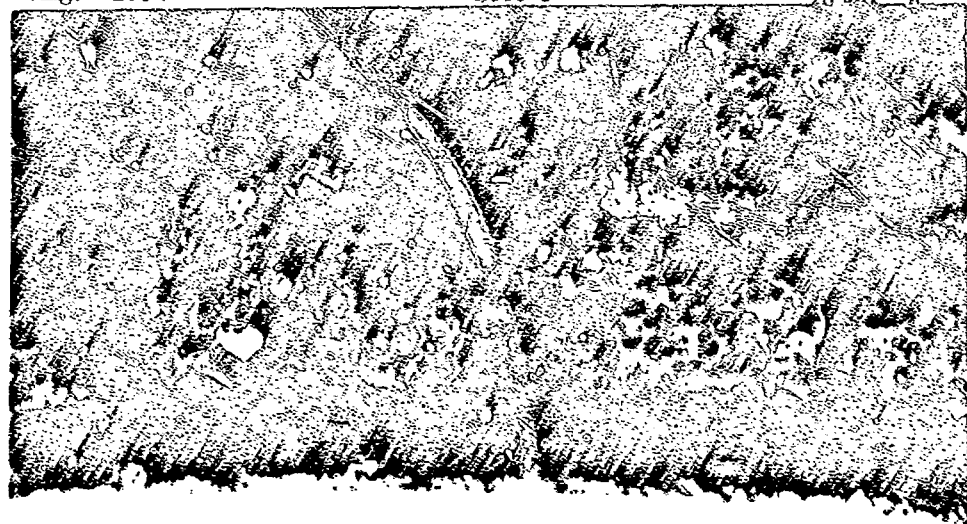


Chemical Corrosion and Pitting

M 4532
Mag: 100X

Lead Monoxide on A-286
1800°F

Figure 391
Etch: H



Oxidation and Pitting

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M 4533
Mag: 250X

Lead Monoxide on René 41
1800°F

Figure 392
Etch: U



Chemical Corrosion

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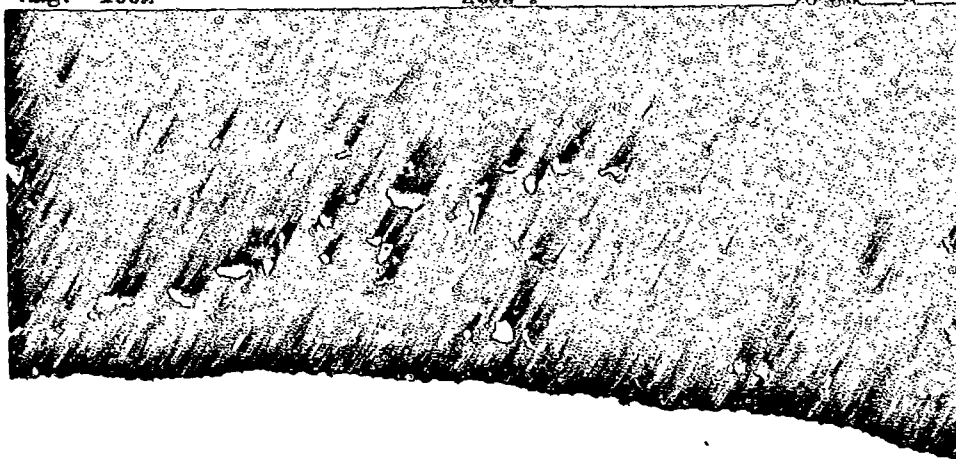
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M 4534
Mag: 100X

Lead Monoxide on L-605
1800°F

Figure 393
Stch: U

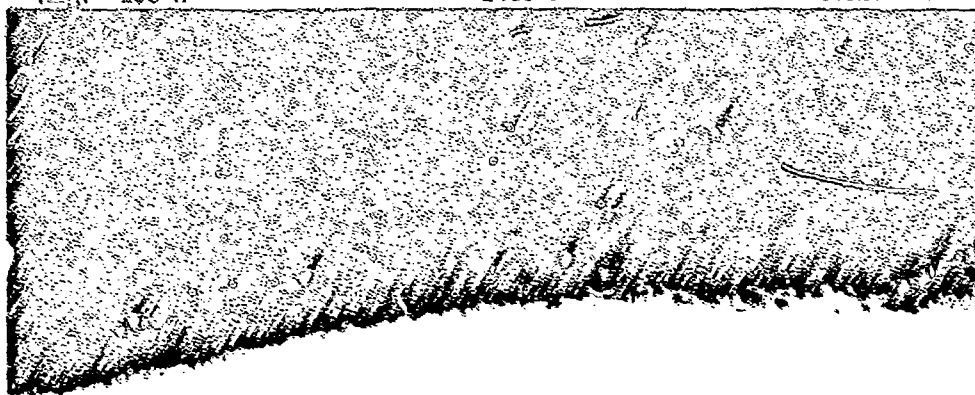


Scale Oxidation

M 4535
Mag: 100 X

Lead Monoxide on Hastelloy X
1800°F

Figure 394
Stch: U



Oxidation

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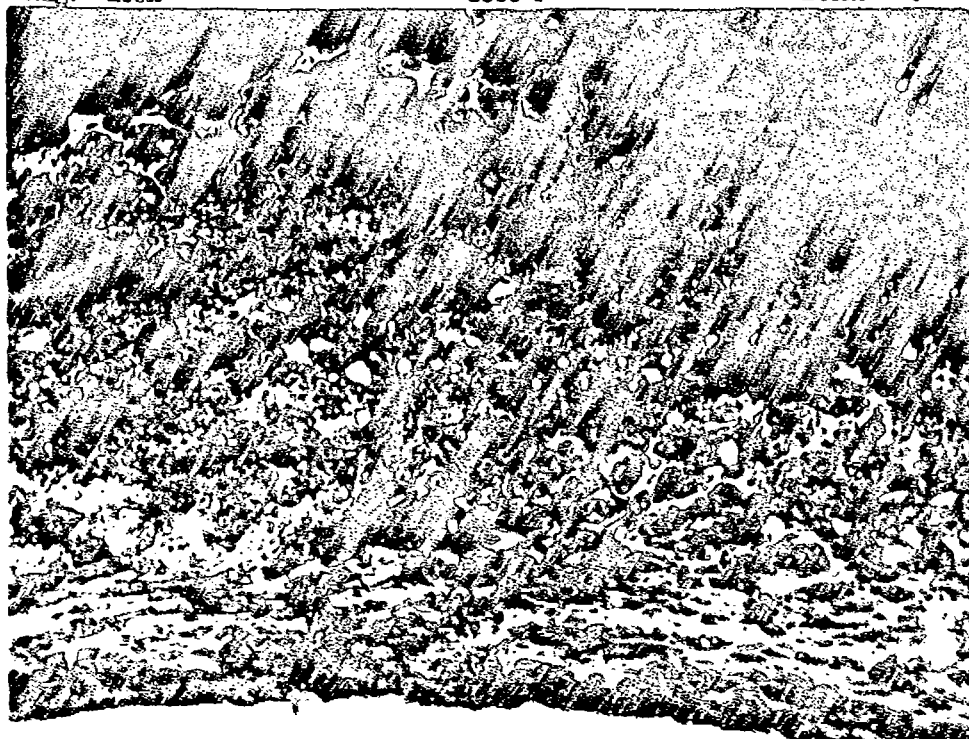
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M 4536
Mag: 100X

Lead Monoxide on 310 SS
1800°F

Figure 395
Etch: U



Oxidation

M 4537
Mag: 500X

Calcium Fluoride on Inconel X
1875°F

Figure 396
Etch: II



Oxidation and Pitting

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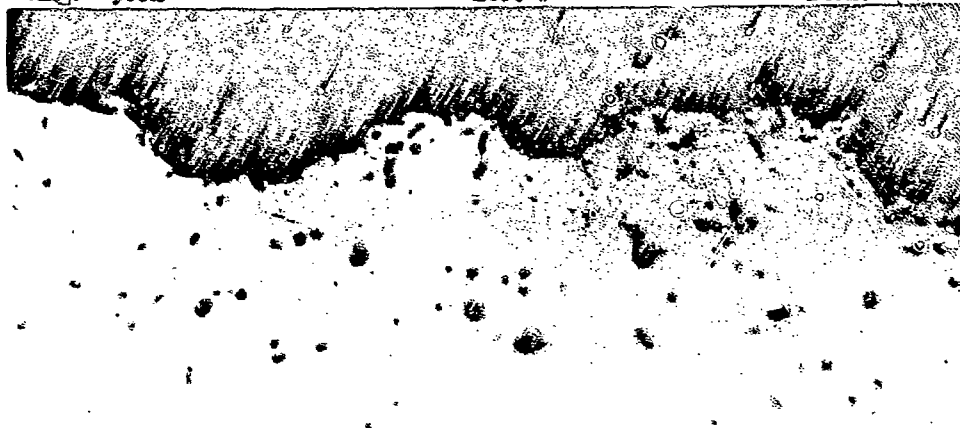
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N 4538
Mag: 500X

Calcium Fluoride on A-286
10000X

Figure 397
Etch: U



Pitting

N 4539
Mag: 500X

Calcium Fluoride on Steel 41
10000X

Figure 398
Etch: U



Oxidation

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BY: LONNIE G. MARRASCH

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M 4940

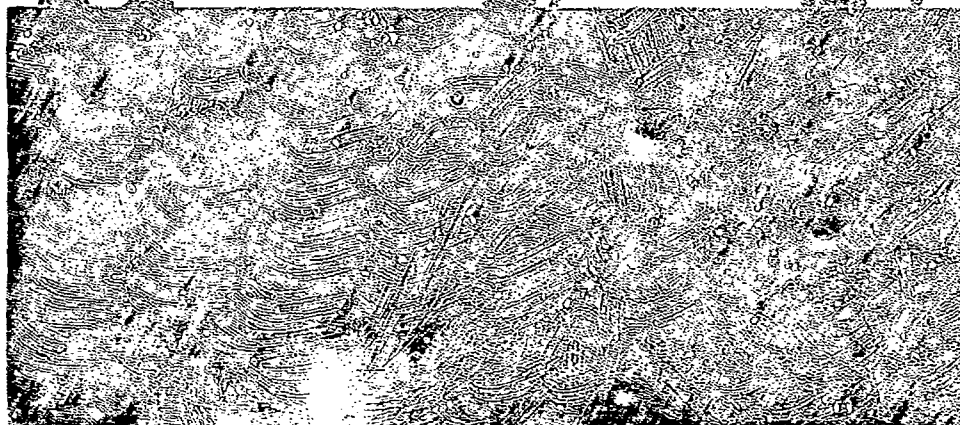
Calcium Fluoride on L-605

Figure 399

Mag: 500X

180007

Sheet: 1



Oxidation

M 4941

Calcium Fluoride on L-605

Figure 400

Mag: 500X

180007

Sheet: 2



Oxidation and Microstructure

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M 4542
Mag: 500X

Calcium Fluoride on 310 SS
1800°F

Figure 401
Etch: U

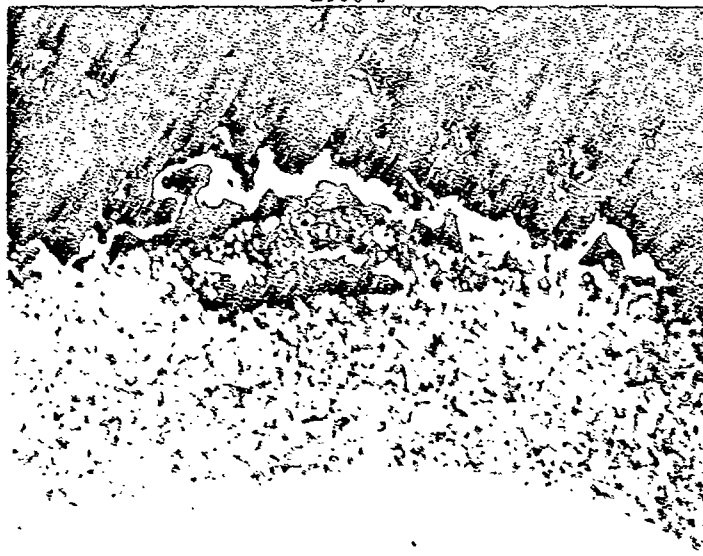


Slight Pitting and Intergranular Oxidation

M 4543
Mag: 50X

Lead Sulfide on Inconel X
1800°F

Figure 402
Etch: U



Extreme Corrosive Alloying

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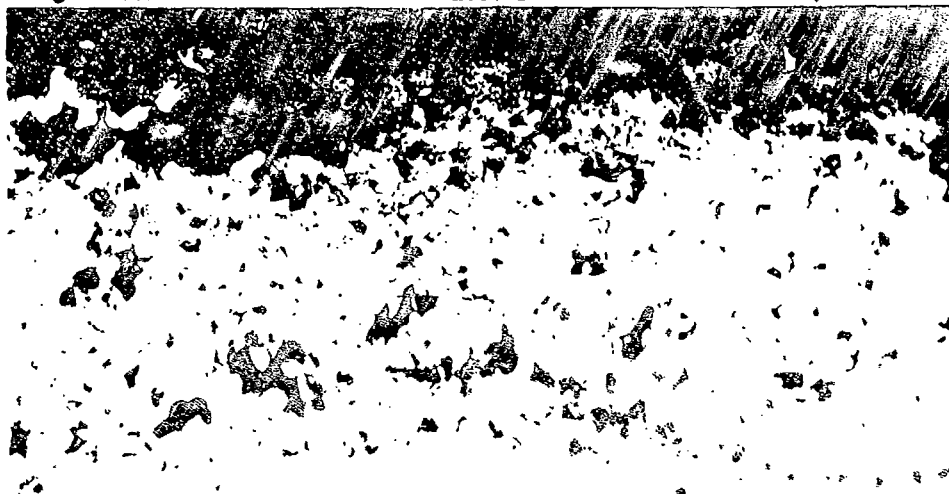
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M 4544
Mag: 100X

Lead Sulfide on A-286
1800°F

Figure 403
Etch: U



Extreme Corrosive Alloying

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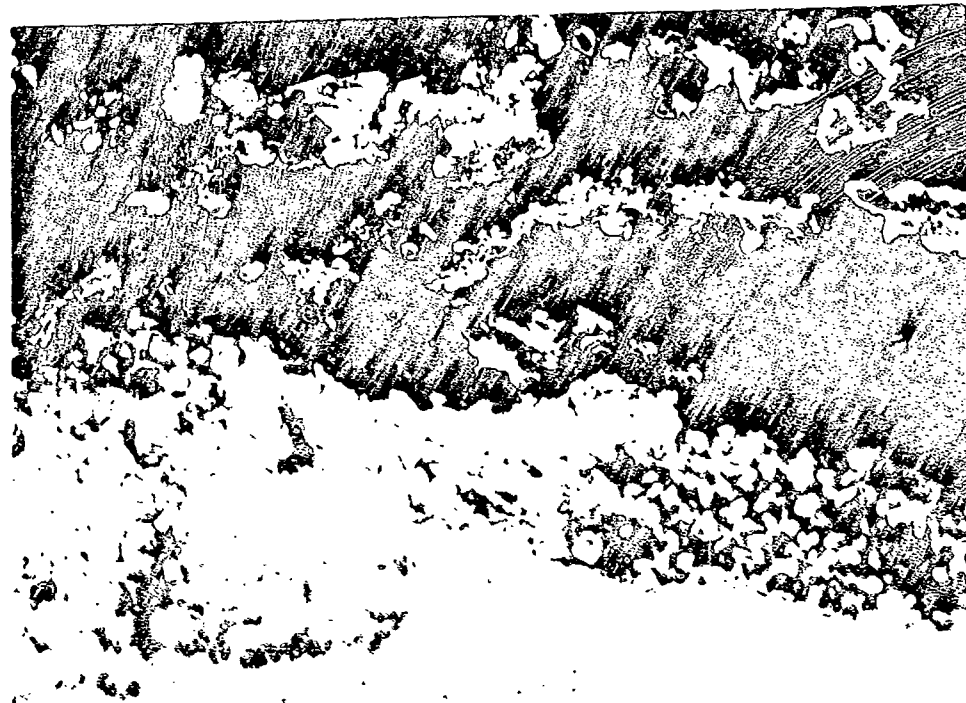
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M 4545
Mag: 100X

Lead Sulfide on René-41
1800°F

Figure 404
Etch: U



Extreme Corrosive Alloying

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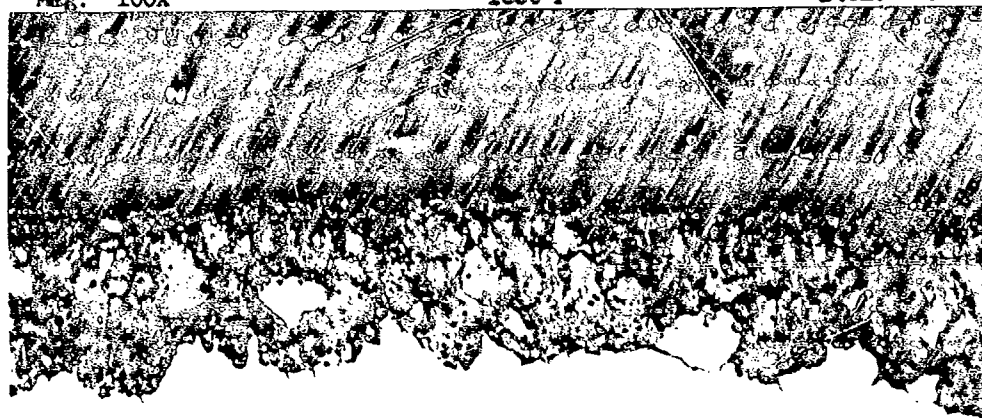
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M 4546
Mag: 100X

Lead Sulfide on L-605
1800°F

Figure 405
Etch: U

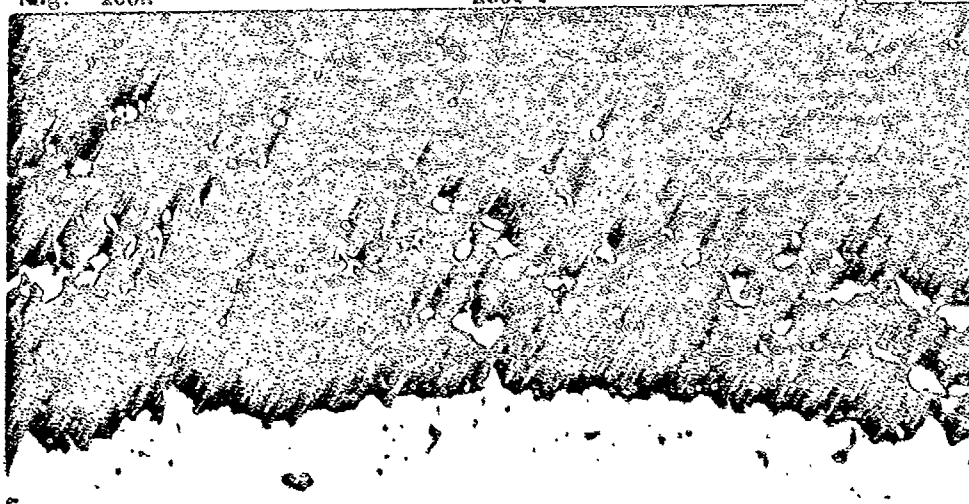


Extreme Corrosive Alloying

M 4547
Mag: 100X

Lead Sulfide on Hastelloy X
1800°F

Figure 406
Etch: U



Extreme Corrosive Alloying

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M 4548

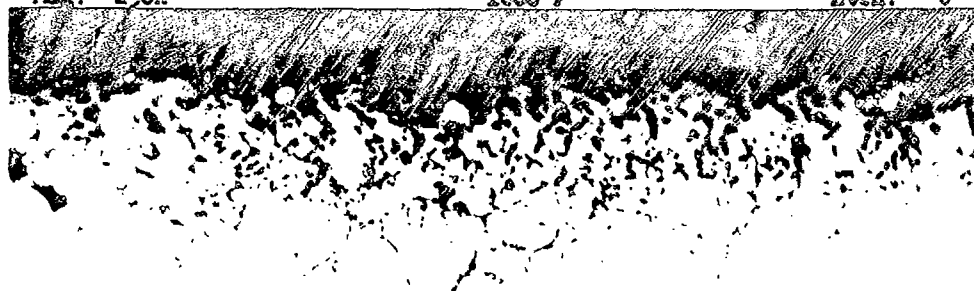
Lead Sulfide on 310 SS

Figure 407

Mag: 250X

1800⁰7

Etch: U



Intergranular Corrosion

M 4549

Inconel X in Air (Control

Figure 408

Mag: 500X

1800⁰7

Specimen

Etch: U



Intergranular Oxidation

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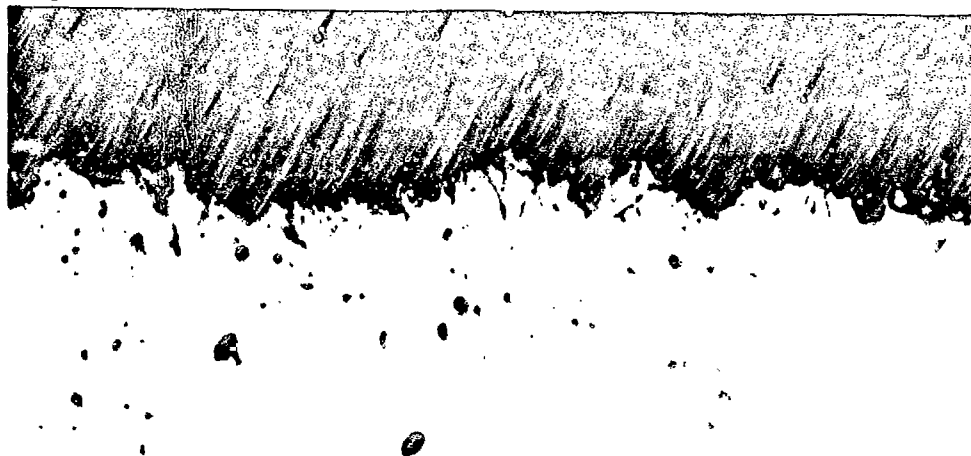
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M 4550
Mag: 500X

A-286 in Air (Control Specimen) Figure 409
18000°F Etch: U



Pitting

M 4551
Mag: 500X

Rens-41 in Air (Control Specimen) Figure 410
18000°F Etch: U



Film and Intergranular Oxidation

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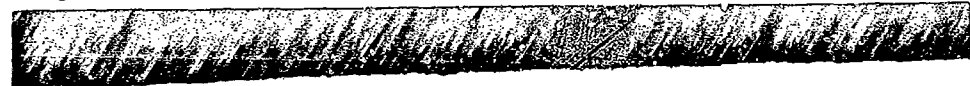
M 4552
Mag: 500X

L-605 in Air (Control Specimen) Figure 411
18000% Etch: U



M 4553
Mag: 500X

Hastelloy X in Air (Control Specimen) Figure 412
18000% Etch: U



M 4554
Mag: 500X

310 SS in Air (Control Specimen) Figure 413
18000% Etch: U



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DATE _____

REVISED _____

REVISED _____

MCDONNELL *Aircraft*

ST. LOUIS, MO

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TEST REQUEST

PAGE 197
REPORT A078

TITLE THE EFFECT OF ANTISEIZING COMPOUNDS AND LUBRICANTS

ON HIGH TEMPERATURE ALLOYS AT ELEVATED TEMPERATURE

LABORATORY OR DEPT. RESPONSIBLE FOR TEST

Department 655, Materials Lab.

MODEL

Misc.

TEST PARTS ON IBM ☐ ON TPL NO.

PRODUCTION PARTS FOR TEST NOT REQUIRED ☒

AP/EM

None

WORK REQUESTED

OBJECTIVE (GIVE PURPOSE OF TEST, WORK AND DATA REQUIRED
INCLUDES SERVICE HISTORY AND BACKGROUND INFORMATION)

- (B) 1. OBJECT: *Rev. B* Revised pages 1, 2 and 3 to correct callouts and substitute compounds. *No prob. 11/14 required R. Mills*
To determine the metallurgical effect that antiseizing compounds have on super alloys at elevated temperature.

2. HISTORY:

The uses of antiseizing compounds on super alloys, particularly at elevated temperatures, may result in serious consequences. Very little information is available concerning the metallurgical effects when using these compounds.

Work on this T.R. will be done in two phases. The first phase is checking for metallurgical effects on the alloys per the basic T.R. Later, an addendum will be added to check the effect of these compounds in threaded connections.

3. MATERIALS:

3.1	ALLOY	SPEC.	SIZE
3.1.1	Inconel X	AMS 5667	1/4" to 1/2" dia.
3.1.2	A-286	AMS 5735	1/4" to 1/2" dia.
3.1.3	Rene' 41	Commercial	1/4" to 1/2" dia.
3.1.4	L-605	AMS 5759	1/4" to 1/2" dia.
3.1.5	Hastalloy X	AMS 5758	1/4" to 1/2" dia.
3.1.6	310 Stainless Steel	AMS 5651	1/4" to 1/2" dia.
3.1.7	4130 Steel	MIL-S-6758	Same dia., but Cond. C 3 ft. long

*Depends on availability. All specs. should be same diameter.

3.2 Compounds

3.2.1 Silver Goop-Jackson Supply Co., St. Louis, Mo.

REFERENCES OR ENCLOSURES

*IDEP SUMMARY RPT REQUESTED.

Rev. A Approved: *Blackman / E.M. Pappas*
3-17-61

3.2.2 Crane #425A - Crane Plumbing Supply Co., St. Louis

3.2.3 Easy Off #990 - Taxacore Co.

3.2.4 Fel-PRO-C-5 - Available at M.A.C.

3.2.5 DCZ 123 - Miracle Power Products, Cleveland, Ohio

~~3.2.6 Motor Mica Paste - Lubricol Corp. - D. 654~~

3.2.7 MIL-T-5544A - Available at M.A.C.

3.2.8 Electrofilm 1000 - Dynacraft Corp., St. Louis

3.2.9 Electrofilm 1005 - " " "

3.2.10 Electrofilm 2006 - " " "

3.2.11 Electrofilm 66C - " " "

3.2.12 Phosphatherm RM, Alpha Molykote Corp., Stamford, Conn.

3.2.13 Molykote X-106M - Available in D. 655 - Test only at 1000°F (3)

3.2.14 Sodium Silicate (powder) - Available in D. 655

3.2.15 Silica (~~in solution with acetone~~) - Available in D. 655

3.2.16 Milk of Magnesia - Available in D. 655

3.2.17 Magnesium Oxide (fine powder) - Available in D. 655

3.2.18 Boron Nitride - Available in D. 655

3.2.19 Boric Oxide - Available in D. 655

~~3.2.20 Polyphosphate I-106~~ - Available in D. 655

3.2.21 Lead Monoxide - Available in D. 655

3.2.22 Calcium Fluoride - Available in D. 655

3.2.23 Lead Sulfide - Available in D. 655

NOTE: If a vehicle is needed for any of the above compounds, contact R. Kollmansberger, D. 654.

3.3 Fixture Materials

3.3.1 301 stainless steel tubing 2 1/2" O.D. x .065 wall thickness X 5' long. 3 1/2" " " " 2.0" " " "

3.3.2 301 S.S. sheet MIL-S-5022 .090" X 24" X 36"

3.3.3 316 S.S. wire (QQ-W-423) .030" dia. X 15'

NOTE: If 301 stainless steel is not available, use 302, 304, or 321 stainless.

4. PROCEDURE:

4.1 Specimen Preparation

4.1.1 Cut each bar into 1.25" lengths and drill a 1/8" hole near one end.

4.1.2 Heat treat the alloys of paragraph 3.1 according to the following procedure. All heat treats shall be done in calibrated furnaces.

a. Inconel X	MAC P.S. 15924
b. A-286	MAC P.S. 15928
c. Rene' 41	MAC P.S. 15602
d. L-605	No heat treat req'd.
e. Hastelloy X	No heat treat req'd.
f. 310 S.S.	No heat treat req'd.
g. 4130 Steel	MAC P.S. 15013

4.1.3 Machine all specimens to remove scale.

4.1.4 Fabricate test fixture per Figure I. (24 req'd.)

4.2 Testing

4.2.1 1000°F exposure

- Place one specimen of each alloy in every container. Each container will then have seven specimens for this exposure temperature.
- Add the 23 antiseizing compounds to their individual containers and identify. Make sure that the alloy specimens are not exposed to air. The one remaining container and its specimens will be exposed to temperature without any compound.
- ~~Weld shut, and~~ Expose to 1000°F for 10 hrs. Then air cool. Remove specimens from the container.

4.2.2 1800°F exposure

(For this temperature, the 4130 specimens are omitted.) With a new group of specimens, repeat procedure of 4.2.1 (a) through 4.2.1 (c) except that the temperature is now 1800°F. Expose for 10 hrs., then air cool. If at all possible, use the same containers that were used at 1000°F.

4.2.3 Prepare transverse metallographic specimens of all specimens.

NOTE: The first 9 compounds to be tested are:

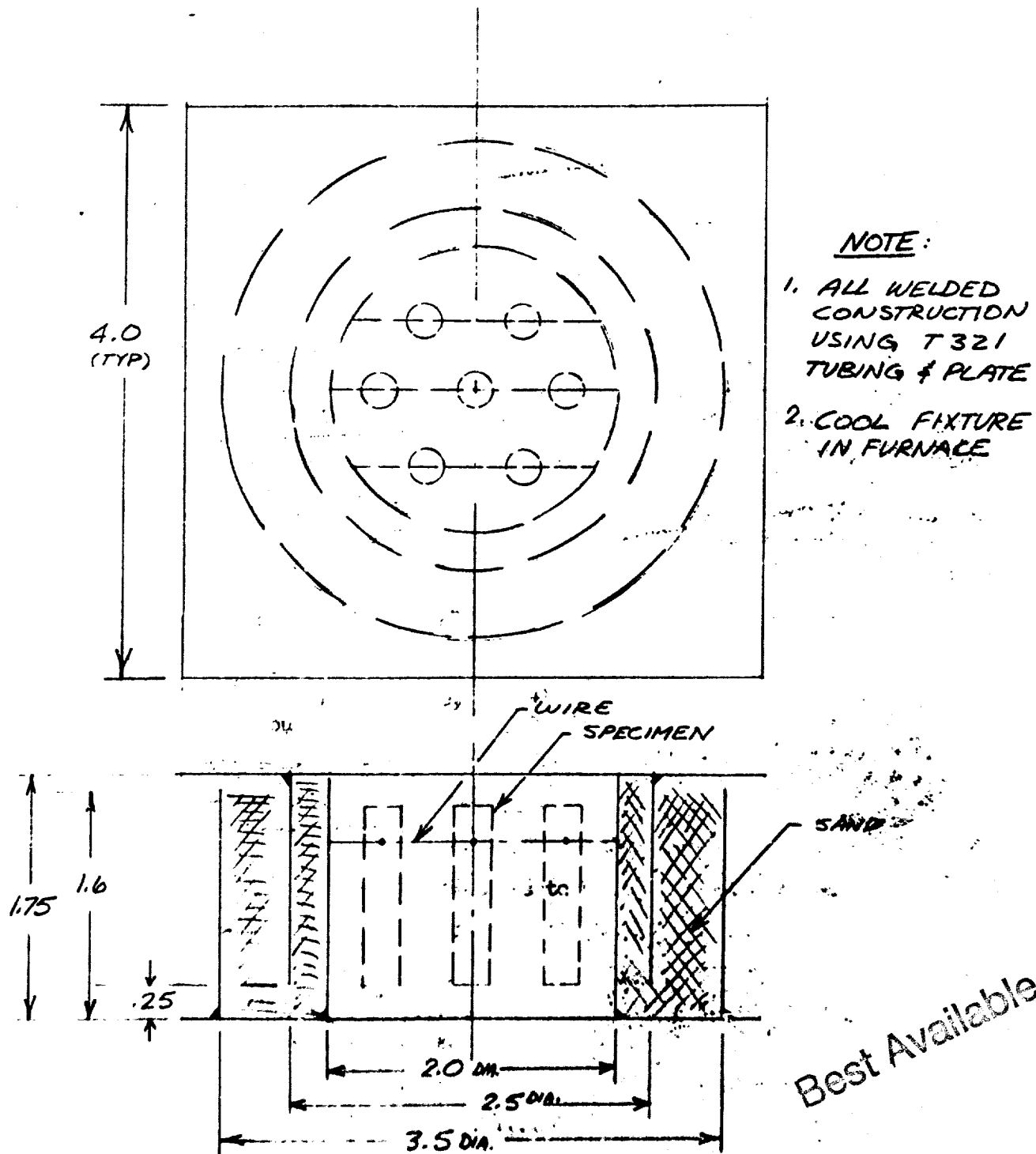
Molykote X-106M	Lead Sulfide
Silica	Boric Oxide
Lead Monoxide	Electrofilm 1000
Tungsten Disulfide	CBS Process GID 5940
Calcium Fluoride	

After these, the order of testing is not important.

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5. DATA REQUIRED:

5.1 Photomicrographs at 250X's for each specimen tested.



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